164 Eglinton Avenue East Toronto Ontario M4P 1G4 (416) 482-5131

HUMAN FACTORS IN RAIL PASSENGER CAR DESIGN

prepared by:

Tom Hay, Ph.D.
Ben Barkow, Ph.D.

with the assistance of:

Dorian Wallis, M. Phil.
Betty Scalzitti

prepared for:

Transportation Development Centre
Transport Canada

August 1984

TP 5488E

Behavioural Team

HUMAN FACTORS
IN
RAIL PASSENGER
CAR DESIGN

TP 5488E

Library and Information Centre
Centre de Documentation (CDL)
RECEIVED — REÇU LE
DEC [illegible] 1984
Government [illegible]
Transport Canada | Transports Canada

PREPARED BY: Tom Hay, Ph.D.
Ben Barkow, Ph.D.

with the assistance of:

Darian Wallis, M.Phil.
Jonathan Siegel, M.Ed.
Betty Scalzitti

PREPARED FOR: Transportation Development Centre
Transport Canada

Ruth Heron, Ph.D.
Senior Research Officer

AND

VIA Rail Canada Inc.
Tim Secord, P.Eng.
Director of Engineering

DATE: August 1984

The contents of this report reflect the views of the contractor and not necessarily the official views or policies of the Transportation Development Centre, Transport Canada, or VIA Rail Canada Inc.

REPORT DOCUMENTATION FORM

1. **Transport Canada Report No.** TP 5488E	2. **TDC Project No.** 4816	3. **Recipient's Catalogue No.**
4. **Title and Subtitle** Human Factors in Rail Passenger Car Design		5. **Report Date** May 1984 6. **Performing Organization Report No.**
7. **Author(s)** Tom Hay, Ph.D., and Ben Barkow, Ph.D.		8. **Transport Canada File No.** D1465-389-2
9. **Performing Organization Name and Address** Behavioural Team 164 Eglinton Ave. E., Suite 505 Toronto, Ontario M4P 1G4		10. **DSS File No.** 12SD. T8200-2-2554 11. **DSS or Transport Canada Contract No.** 0SD83-00017
12. **Sponsoring Agency Name and Address** Transportation Development Centre 1000 Sherbrooke Street West Suite 2421 Montreal, Quebec H3A 2R3	VIA Rail Inc. 2001 University Montreal, Quebec H3A 2A6	13. **Type of Report and Period Covered** Final: May/83 - April/84 14. **Sponsoring Agency Code** TDC
15. **Supplementary Notes**		16. **TDC Project Officer** Ruth M. Heron, Ph.D.

17. **Abstract**

This report provides a comprehensive review of human-factors for long-distance passenger train travel. A general overview of the work is presented in the main body of the report. The detailed findings and recommendations are contained in appendices which correspond to the major tasks of the study.

These tasks were as follows:

1. Developing a taxonomy of all of the possible human-factors issues for long-distance train passengers. (This taxonomy provided the framework for the remaining tasks.)
2. reviewing the relevant psychological and ergonomic literature,
3. analysing current Canadian practice in enclosed accommodation in various modes of public and personal transportation
4. conducting a similar analysis of state-of-the-art international practice,
5. comparing Canadian and international practice with specific regard to long-haul passenger trains,
6. formulating functional design guidelines for addressing human-factors issues in the design of new long-distance trains for the Canadian market and, finally,
7. describing the most important gaps in our understanding of human-factors that affect comfort and enjoyment on long-distance train trips, and suggesting research to fill these gaps.

18. **Key Words** Intercity rail, train, rail car design, passengers, ergonomics, human factors, comfort	19. **Distribution Statement** Limited number available from the Transportation Development Centre

20. **Security Classification (of this report)** Unclassified	21. **Security Classification (of this page)** Unclassified	22. **No. of Pages**	23. **Price** N/A

TDC/CDT 79-005

FORMULE DE DOCUMENTATION POUR RAPPORT

1. Nº du rapport Transports Canada
TP5488E

2. Nº de l'étude — CDT
4816

3. Nº de catalogue du destinataire

4. Titre et sous-titre
Human Factors in Rail Passenger Car Design

5. Date du rapport
mai 1984

6. Nº du rapport de l'organisme exécutant

7. Auteur(s)
Tom Hay, Ph.D., and Ben Barkow, Ph.D.

8. Nº de dossier Transports Canada
D1465-389-2

9. Nom et adresse de l'organisme exécutant
Behavioural Team
164 Eglinton Ave. E., Suite 505
Toronto, Ontario
M4P 1G4

10. Nº de dossier — ASC
12SD. T8200-2-2554

11. Nº de contrat — ASC ou Transports Canada
0SD83-00017

12. Nom et adresse de l'organisme parrain
Centre de développement des transports
1000 ouest rue Sherbrooke
suite 2421
Montréal, Québec H3A 2R3

VIA Rail Inc.
2001 rue université
Montréal, Québec
H3A 2A6

13. Genre de rapport et période visée
finale: mai/83 - avril/84

14. Code de l'organisme parrain
CDT

15. Remarques additionnelles

16. Agent de projet — CDT
Ruth M. Heron, Ph.D.

17. Résumé

Le présent rapport passe en revue les facteurs ergonomiques à considérer dans la conception des matériels de transport ferroviaire sur longues distances. Un aperçu général des travaux est donné dans le corps principal de ce document, tandis que les conclusions et recommandations figurent dans les annexes consacrées aux phases suivantes de l'étude:

1. recensement systématique de tous les facteurs ergonomiques susceptibles d'intervenir lors des longs voyages en train (relevé a constitué le point de départ pour la réalisation des autres phases de l'étude);
2. examen des traités de psychologie et d'ergonomie pertinents;
3. analyse des pratiques ayant cours au Canada en matière d'aménagement intérieur des matériels de transport en commun et privé;
4. analyse des pratiques actuelles correspondantes à l'étranger;
5. comparaison des pratiques canadiennes et étrangères dans le domaine particulier des matériels de transport ferroviaire de passagers sur longues distances;
6. élaboration de lignes directrices pour la conception de matériels voyageurs canadiens qui tiennent compte des facteurs ergonomiques dégagés;
7. mise en évidence des principales lacunes dans nos connaissances en matière d'ergonomie des transports sur longues distances et des recherches qui permettraient de les combler.

18. Mots-clés
Transport ferroviaire, trains, conception des matériels ferroviaires, voyageurs, ergonomie, facteurs humains, confort.

19. Diffusion
Le CDT dispose d'un nombre limité d'exemplaires.

20. Classification de sécurité (de ce rapport)
Non-classifié

21. Classification de sécurité (de cette page)
Non-classifié

22. Nombre de pages

23. Prix
Aucun

Human Factors in Rail Passenger Car Design

TABLE OF CONTENTS

SECTION 1 - FINAL REPORT

1. Introduction 1
2. Studies of Human Factors Issues for Long Distance Train Travel in Canada 2
3. Conclusions 9

note: the following interim reports each contain a detailed table of contents

SECTION 2 - INTERIM REPORT A: TAXONOMY OF HUMAN FACTORS FOR PASSENGER RAIL DESIGN

.... 1 - 7

SECTION 3 - INTERIM REPORT B: LITERATURE REVIEW

.... 1 - 100

SECTION 4 - INTERIM REPORT C: CURRENT CANADIAN PRACTICE

.... 1 - 30

SECTION 5 - INTERIM REPORT D: CURRENT INTERNATIONAL PRACTICE

.... 1 - 32

SECTION 6 - INTERIM REPORT E: COMPARISON OF CANADIAN AND INTERNATIONAL PASSENGER RAIL SYSTEMS

.... 1 - 12

SECTION 7 - INTERIM REPORT F: DESIGN GUIDELINES FOR LONG DISTANCE PASSENGER TRAINS

.... 1 - 31

SECTION 8 - INTERIM REPORT G: ASPECTS OF LONG DISTANCE TRAIN DESIGN REQUIRING FURTHER RESEARCH

.... 1 - 26

SECTION 9 - BIBLIOGRAPHY

.... 1 - 47

SECTION 10 - APPENDXIX A: SOURCES OF INFORMATION

.... 1 - 3

BEHAVIOURAL TEAM, A CORPORATION
164 EGLINTON AVENUE EAST, TORONTO, ONTARIO M4P 1G4 (416) 482-5131

HUMAN FACTORS IN RAIL PASSENGER CAR DESIGN

1. INTRODUCTION

The purpose of this project has been to investigate the human factors issues involved in long-distance passenger train travel. Human factors involves all of the design and operational features that affect riders. The role of human factors is to ensure that operation is safe, effective, efficient, comfortable, and satisfying. This should be from both the rider's and the operator's viewpoint! Human factors in long-distance passenger trains cover all of the equipment and service features that relate to passenger comfort and satisfaction.

Most of the equipment now used in Canadian transcontinental service is outdated in terms of design and technology. As one of the first steps in replacing this equipment, VIA Rail Canada and the Transportation Development Centre of Transport Canada wisely requested proposals to review both the applied psychology literature and the practical applications of human factors as it applies to train journeys lasting from six hours to six days.

Behavioural Team were selected for the contract based on our proposal and our past record in studies of human factors in transportation and other public settings. We began the project in May of 1983. Throughout the project we have been assisted by many people. Although we cannot individually acknowledge every contribution, we have tried to list those persons who were especially helpful in the relevant appendix (A). We also received much valuable input and guidance from the project Advisory Committee - Dr. Ruth Heron and Brian Marshall of the Transportation Development Centre, and Tim Secord and Pamela Rice of VIA Rail.

The main tasks of the project are listed below. Each task is then described briefly in the next section of the report. Detailed interim reports were made at the completion of each task. These interim reports make up the appendices to this final report.

The tasks involved in our review of human factors for long-haul trains were to:

1. develop a taxonomy of human factors considerations for long-distance train passengers (Interim Report A),

2. conduct a search of the ergonomic and psychological literature and a review of the relevant articles (Interim Report B),

3. review current Canadian practice regarding vehicle accommodations with regard to both equipment and services (Interim Report C),

4. carry out a similar review for international practice in various vehicle accommodations (Interim Report D),

5. compare and contrast the Canadian and international practice with specific regard to train accommodations and services (Interim Report E),

6. prepare descriptive design guidelines which summarize the latest human factors knowledge concerning passengers needs and preferences (Interim Report F),

and

7. identify the human factors issues which require further research in the context of long-distance train travel (Interim Report G).

A single BIBLIOGRAPHY lists all of the references for the final and interim reports. Other sources of information which Behavioural Team made use of are listed in APPENDIX A.

2. STUDIES OF HUMAN FACTORS ISSUES FOR LONG-DISTANCE TRAIN TRAVEL IN CANADA

2.1. A Taxonomy of Human Factors Needs For Train Travellers

A taxonomy is a classification system that divides some set of concepts into a hierarchy of major groups and their subgroups. In this case, the human factors issues involved in long-distance train travel were organized into a taxonomy. This thorough taxonomy then provided the basic structure for the remaining studies. This approach ensures that all of the relevant topics receive attention in an organized manner. The range of possible passenger activities is quite large on a train trip lasting overnight or several days and nights. Adequate consideration of the human factors of each of these activities will enhance the comfort and satisfaction of passengers.

Behavioural Team prepared the "Rail Travellers Needs Taxonomy" based on some similar human factors taxonomies for work tasks we had developed previously, and based on many years of experience in transportation human factors. Some items were added to the taxomomy by the Advisory Committee. The entire taxonomy can be found in Interim Report A. The major headings are listed in the brief version below. The taxonomy is intended to cover all of the aspects of the train and service that affect the passengers' comfort and satisfaction during the trip.

RAIL TRAVELLERS NEEDS TAXONOMY
(condensed version)

I. GENERAL ENVIRONMENTAL VARIABLES

A. Temperature
B. Air quality
C. Auditory stimuli
D. Vibrations
E. Accelerations
F. Lighting
G. Signs
H. Other visual stimuli
I. Space
    1. Public spaces
    2. Accommodation spaces

II. BEHAVIOURAL VARIABLES (in sequential order)

A. Boarding and alighting the train
B. Locating your "territory" on the train
C. Handling luggage
D. Activities in the accommodation space
    1. Sitting
    2. Reclining
    3. Reading
    4. Talking and social interactions
    5. Playing games
    6. Sightseeing (looking out the window)
    7. Working
    8. Self care (space required, preferred location, baggage access)
    9. Care of travelling companions
    10. Sleeping
    11. Intimate social behaviours (both positive and negative)
    12. Smoking
E. Transitions between accommodation space and public space
F. Activities in common or public spaces
    1. Aisles
    2. Washrooms, toilets
    3. Lounges, snack bars and restaurants
G. General Psychological considerations
    1. Regulation of human contact
    2. Relation between perceived cost of furnishings and "comfort"
    3. Relation between perceived cleanliness and "comfort"
    4. Perceived and actual safety
    5. Phobias, fears
    6. Stress reduction
    7. Entertainment, festivities
    8. Special travel groups
    9. Travelling with pets, valuable livestock, etc.

III. Interactions with rail personnel

A. Identifying help, information, or authority figures
B. Training and demeanor of staff
C. Emergency management

2.2. Review of the Literature

The next task called for a search of the ergonomic and psychological literature for articles relevant to human factors on long train trips and review of the most relevant articles. This review is contained in Interim Report B. We used on-line searches of a variety of databases on the Dialog and CAN/OLE systems. Judith Nogrady of the TDC Library was most helpful in this effort.

This computer-based search was supplemented by a manual search of rail and human factors abstracts, library holdings of related books and articles, and Behavioural Team's own extensive collection of relevant books and papers.

One of the main findings of this review was that there really isn't very much well-researched information about trips ranging from six hours to six days in duration. Most of the laboratory studies of passenger comfort have been limited to exposures of three hours or less. Few field studies or surveys have dealt with long-distance train passengers either. Most of the articles reviewed were of limited applicability to Canadian transcontinental train service.

Many of the most relevant articles came from periodicals dealing specifically with railways. The design of newer coaches and sleeping compartments has incorporated some human factors information. This is evident in discussions of the design of specific features such as automatic doors and sound insulation for sleeping compartments. However, Behavioural Team's review of the literature found no systematic treatment of the range of human factors issues.

There are articles which deal with specific human factors issues that have some relevance to the design of new Canadian long-distance passenger rail cars. Most of these are based on considerations that are not unique to passenger rail travel, though. They deal with general design considerations such as lighting requirements for different tasks, choice of seating arrangement by different size social groups, and design guidelines for living and working spaces. Behavioural Team's review of the literature brings all of these different sources together and describes their relevance to long-distance passenger rail travel.

This literature review provides an overview of the human factors considerations that have been described in available published reports. There are many sorts of mobile accommodation for passengers. The ones used on trips ranging from six hours to six days run the gamut from luxury yachts to intercity buses. But the design features are rarely described in published articles. The next sections deal with human factors practices in enclosed accommodations.

2.3. Current Canadian Practice in Enclosed Accommodation

Behavioural Team used a variety of techniques to review the current practice in passenger accommodation in Canada. We used letters, interviews, observations and field measurements to determine the human factors characteristics of different vehicles. Some of our field observations and measurements were made during authorized inspections of equipment while others were made "unofficially" when Behavioural Team staff were passengers in various vehicles. The features and designs that affect passenger comfort and satisfaction are described in Interim Report C.

For long duration trips within Canada, passengers can take a personal auto, a motor home or trailer, a bus, or a train. The personal auto is very different from the other vehicles in terms of the accommodation for the passengers and the human factors issues involved. Auto passengers cannot stand up, walk around, or go to the washroom without leaving the vehicle. The auto, of course, has advantages in terms of flexibility and personal control, and disadvantages in terms of safety and comfort. Since its human factors considerations are so different, automobiles are not analyzed further in this report.

The type of personal accommodation available on long-distance trains ranges from a seat in a coach to a deluxe room with toilet and sink. These are analogous respectively to seating on an inter-city bus and travel in a motor home. The train also offers several other areas such as dining or lounge cars, snack bars, and even observation areas. Travel by private yacht or commercial ferry in Canada is also relevant to a thorough review of long-distance travel accommodation. Behavioural Team's review of the current Canadian practice looks at the accommodation presently offered in all of these different types of vehicles.

Commercial airlines and cruiseships are considered in the review of international practice described next. This section also includes a review of train practices in other countries.

2.4. Current International Practice in Enclosed Accommodation

The next task in our review involved looking at current international practice in vehicular accommodation. The detailed report of this phase is contained in Interim Report D.

Travel conditions around the world vary greatly. In many less developed countries, commercial transportation equipment may offer few amenities. Some passengers may even choose to ride on the outside of the vehicle because it is more comfortable than the hot, crowded interior. On the other hand, there are many examples in the design of passenger equipment - particularly in Europe - where passenger comfort is a major goal in the design.

The modern cruiseships that travel about the Carribean and Mediterranean have rooms that range from cramped to luxurious and a great deal of shared public space. As these ships have been built (or refurbished), designers and naval architects have incorporated some intuitive human factors information into features, decor, and services. In other cases, particularly commercial airlines, the design envelope is so restricted that human factors input is deemed more critical. Commercial airplane design has generally tried to provide minimally acceptable comfort and maximum passenger density. As for most other modes, a more expensive ticket will get you some more space and service. On some long flights you can even get a berth in which to sleep. Some designs, such as the Boeing 747, have public space in the form of a lounge area.

Trains are psychologically somewhere between cruiseships and airplanes in terms of the amount of space available, the types of accommodation offered, and the amount of public space. Railway practices in technologically advanced countries received a great deal of attention in Behavioural Team's review. We accessed information from railway companies in the United States, Australia, New Zealand, Great Britain, and throughout Western Europe.

In addition, Behavioural Team conducted field observations, measurements, and interviews involving several international airlines and European railways. This revealed the latest design practices and human factors considerations involved in new equipment and in the delivery of passenger services. In most cases, human factors considerations have been incorporated in an ad hoc and intuitive manner. The review of human factors issues by Behavioural Team seems to be the first systematic treatment of its kind for long-distance public transportation vehicles anywhere in the world.

The next phase of the work involved comparing and contrasting the current practice in Canada and elsewhere to arrive at sensible conclusions concerning the implications for new, long-distance, Canadian passenger trains.

2.5. Implications of Current Canadian and International Practice

The tasks to this point summarized the published and practical knowledge concerning human factors which relate to long-distance passenger trains in Canada. All of the relevant interim reports (INTERIM REPORTS B-D) have been based on the taxonomy described above. The next task involved comparing and contrasting Canadian and international practice with specific regard to long-distance trains. This report was not based on the taxonomy since it involved analysEs of larger issues such as the comparability of different railways. The detailed comparison of current long-distance railways is contained in Interim Report E.

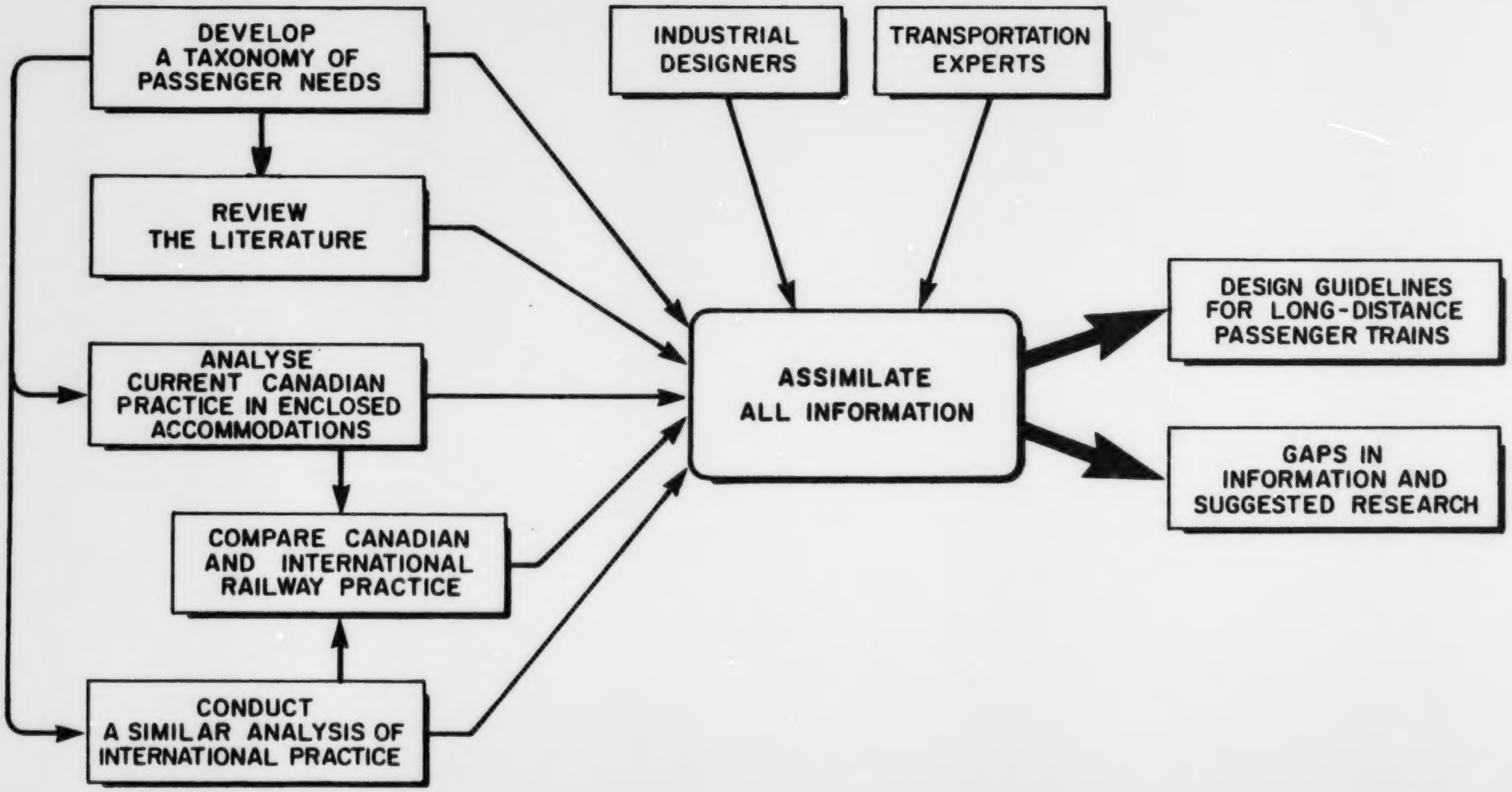
The major issues covered in Behavioural Team's analysis of long-haul passenger trains were -

a) Operating Conditions,
b) Passenger Characteristics,
c) Accommodation Levels,
d) Equipment Designs, and
e) Service Delivery.

Railways around the world have similarities and differences in terms of these five factors. Train designs and railway practices affect things ranging from the environmental quality to passengers' expectations. No other country is exactly like Canada in all of the aspects of long-distance train travel. But we can learn a great deal from the designs, procedures and experiences of railways in other countries. It is especially valuable to learn of human factors problems that have been encountered in the design of new rail equipment elsewhere.

HUMAN-FACTORS IN THE DESIGN OF LONG-DISTANCE RAIL PASSENGER CARS

STUDY PLAN



DEVELOP A TAXONOMY OF PASSENGER NEEDS

REVIEW THE LITERATURE

ANALYSE CURRENT CANADIAN PRACTICE IN ENCLOSED ACCOMMODATIONS

COMPARE CANADIAN AND INTERNATIONAL RAILWAY PRACTICE

CONDUCT A SIMILAR ANALYSIS OF INTERNATIONAL PRACTICE

INDUSTRIAL DESIGNERS

TRANSPORTATION EXPERTS

ASSIMILATE ALL INFORMATION

DESIGN GUIDELINES FOR LONG-DISTANCE PASSENGER TRAINS

GAPS IN INFORMATION AND SUGGESTED RESEARCH

Behavioural Team

AREAS FOR FURTHER RESEARCH

1. ANALYSIS OF PRESENTLY AVAILABLE DATA
2. ON-BOARD STUDIES OF PASSENGERS
3. STUDIES WITH POTENTIAL PASSENGERS
4. HUMAN-FACTORS OF PASSENGERS WITH SPECIAL NEEDS
5. STUDIES USING MOCK-UPS AND PROTOTYPES
6. "FINE-TUNING" OF NEW EQUIPMENT

These observations and comparisons were integrated with the literature review and other sources to complete the last two tasks - describing human factors guidelines for new equipment, and defining the remaining gaps in relevant human factors information and the research necessary to fill those gaps.

2.6. Human Factors Design Guidelines for Long-Distance Passenger Trains in Canada

Behavioural Team's next task in this project was to provide human factors guidelines for the various issues listed in the taxonomy. The purpose was to bring together all of the information from the various sources to provide descriptive criteria for ensuring that the human factors needs of the passengers are met in the design of new equipment. The detailed design guidelines can be found in Interim Report F.

In some cases, it is possible to provide specific and quantitative specifications for space requirements, environmental variables, and the like. For other aspects of the design, it is necessary to provide descriptive guidelines that will point out potential problems or conflicts. In general, the guidelines are meant to apply to the range of passengers. The human factors requirements for travellers with special needs are also addressed.

It is sometimes possible to specify optimal space and environmental conditions given a specific activity and specific population. But it is not economically feasible to incorporate all of the different requirements for every possible activity and kind of passenger into new designs. This would require not only more space in general, but also all sorts of specialized spaces that would only be used occasionally by small segments of the travelling public. Decisions have to be made throughout the design process concerning the compromises that must be made and the accommodations and services that will be offered. These decisions must incorporate human factors, marketing, regulatory, and technical information.

As an example, many newer trains in other countries have two-way telephone communications for passengers. Decisions about whether to incorporate passenger telephones into new Canadian trains depends on specific information about regulatory and technical requirements, costs, space requirements, perceived value to the different sorts of passengers using VIA Rail for long journeys, and implications for other design features.

In addition, the overall design envelope affects the space availability inside the train. For example, if the next generation of Canadian rail cars is going to be double-deck the human factors considerations will be different, in some respects, from the issues involved in the design of a single level train. The width of the design envelope is also critical, since it is not really wide enough for optimal seating in a 2+2 arrangement plus an optimal aisle. This means, among other things, that either wheelchair users can only have access to some portions of the train with wide aisles, or they must transfer to a narrower push chair to negotiate the narrow aisles.

Behavioural Team have been able to provide an organized set of guidelines based on the taxonomy of passenger needs. The critical information that is still unknown concerning the human factors requirements is outlined in the next task. The design of new equipment will require ongoing input from human factors specialists to fill these gaps in our knowledge and to incorporate all of the human factors information into the final design. Since the final design will require compromises in what might be considered "ideal" human factors, behavioural specialists are required to see that the best compromises are made and the implications of these compromises are understood.

The next task outlines the main gaps in our human factors knowledge regarding long-distance train travel and the kind of research required to fill these gaps. This research is important to implement human factors into mock-ups, prototypes, and new trains.

2.7. Aspects of Long-Distance Passenger Train Design Requiring Further Research

A thorough analysis of human factors for a project like this requires summarizing both what we know and what we don't know. The last interim report deals with the gaps in our knowledge about passengers' needs, attitudes, preferences, and expectations concerning long-distance train trips. In addition, Behavioural Team have outlined the kinds of studies required to gather the relevant information in the most efficient manner. The detailed interim report can be found in Interim Report G.

The gaps in the knowledge base range all the way from questions about mechanical design, like the easiest way to operate a fold-out bed, to social design, like the optimum distribution of seats in a lounge area to permit both privacy and socializing. There are important gaps in every area of human factors in long-distance train travel. Behavioural Team have organized these questions according to our human factors taxonomy. Although the questions cover a very broad range, the programs of research required to answer them fall into a few major groups.

There is an orderly progression among the suggested studies. The first series should look at the relevant data that is presently available. This should include not only present marketing research, but also any accidents, mishaps, complaints, and staff comments that deal with human factors issues. The information on passengers' responses to the present equipment, service, and operating conditions should be scrutinized with specific human factors questions in mind.

The next programs of research involve three different groups of persons. The first set deals with present passengers in on-board studies. The next focuses on potential passengers, or the "ones that got away." Passengers with special needs should receive special attention. This is necessary both because their needs are different, and because special methods are required to access and study these special groups. Interviews, surveys, and Focus Groups would reveal a great deal about the particular comfort and satisfaction requirements of these groups.

Based on some judgment about which of these needs have priority, construction of mock-ups and prototypes can begin. Mock-ups and prototypes have distinct advantages in human factors research. Different design features can be tried and tested with the relevant subjects. These should include not only the "average" passenger, but also those most likely to experience difficulties.

The final program of research should consist of "fine-tuning" studies on the new equipment. This can help ensure that the designs for equipment and services meet the human factors requirements. Often, early studies of this sort can serve to locate and correct faults before they cause any significant problems for users.

Human factors psychologists should play a role in all of these studies, from the analysis of present data to the "post-occupancy" studies of new equipment in operation. Experienced behavioural professionals can easily choose the most appropriate and cost-effective strategy for answering each of the remaining questions. Their skills are required for dealing with the many special groups and sensitive issues involved. The return for this investment in a thorough analysis of human factors will be new passenger equipment that is maximally safe, optimally comfortable and satisfying to the passengers, and as economical as possible in terms of operation and maintenance.

3. CONCLUSIONS

Throughout this project, Behavioural Team have reviewed the whole gamut of human factors issues for passengers on long train trips. We have looked at both the research and practice here in Canada and around the world. We have integrated this information to produce design guidelines and plans for filling the gaps in knowledge.

For the most part, this information is organized according to the taxonomy of passenger needs. This structure makes it easy to find the relevant sections dealing with a specific issue. Consequently, we will not try to review these issues individually here. However, some comments are in order about the relationships between the different human factors issues, the compromises that must be made to accommodate passengers on long-distance trains, and a few other points that don't fit neatly into the taxonomic organization.

First, the design envelope of a train is constrained in all dimensions so space inside each coach is limited. The operating expenses increase with the number coaches bought, maintained, and hauled. Therefore, space on the train is at a premium. This means that compromises must be made in the amount of space allotted to different functions. These constraints mean, for example, that the coach seats cannot be big enough for those in the heaviest 1% of the population, and the aisles cannot be wide enough for the widest mobility aid, or for two large persons with suitcases in each hand to pass each other comfortably.

The fact that these compromises must be made necessitates human factors input throughout the design. After deciding on a conceptual design (ie. single vs double-deck, coach length, and proposed consists) the exact design envelope can be defined. Then the behavioural expert can help make some initial decisions on the comfort and satisfaction effects of various interior layouts. These can be tested in studies of responses to mock-ups and prototypes. This testing also requires human factors expertise.

The necessary compromises should be based on continued human factors, marketing, and technical research. Decisions should not be made merely on technical expediency, intuition, short-term economies, or the unsupported preferences of the equipment supplier. This means that human factors expertise should have a small but consistent place on a design team from start to finish.

Another implication of the human factors compromises is that not everyone will be comfortable or satisfied on a long train trip. The task is to optimize comfort and satisfaction within the constraints. This requires a clear analysis of who is affected by each of the constraints, and what are the consequences. The issue is complicated because it is not a typical marketing situation. Since VIA Rail is a national public carrier, it is expected to offer a high degree of service to a broad range of Canadians, including those with physical or mental disabilities. Another complication is the annual variations in passenger loadings. VIA has too many passengers in the summer and at Christmas, and not enough the rest of the year. Consequently it is not a simple question of capturing a broad market share by offering the right amenities.

Final decisions on the level of comfort and service offered on long-distance passenger trains in Canada will require a more clearly stated model of the marketing and economic factors involved. Human factors expertise can specify features that are necessary for the comfort and satisfaction of various possible riders. But specific decisions about the minimal level of comfort and satisfaction, and the degrees of additional service or accommodation to be available for additional fare, must take other input into account.

Finally, there are numerous issues regarding the human factors involved in operation and maintenance of long-distance trains. Some of these issues have been touched upon in our reviews of research and practice. But our main focus has been on those factors that impinge directly on the passengers. More research is needed on the human factors of the train staff. This would include a review of the tasks and working conditions of the railway employees, training, situations causing problems for staff, and effects of different designs on delivery of services and maintenance of equipment.

Behavioural Team's review has organized a great deal of information about human factors for passenger rail car design. We have also described some of the general issues affecting the final design, and the research that still needs to be done. We hope that this sort of behavioural expertise will continue to play a prominent role in the design of Canada's next generation of long-distance passenger trains.

BEHAVIOURAL TEAM, A CORPORATION
164 EGLINTON AVENUE EAST, TORONTO, ONTARIO M4P 1G4 (416) 482-5131

TAXONOMY OF HUMAN FACTORS FOR PASSENGER RAIL DESIGN

INTRODUCTION

The taxonomy which follows is intended to identify the major human factors issues related to the design of rail passenger cars for relatively long journeys. For each of the points in the taxonomy there will be numerous aspects to the human factors design criteria. Human factors considerations include the range of potential users and their abilities, maintenance and durability, aesthetic features, optimum use of space, and service delivery, to name a few.

The first section of the taxonomy covers general environmental variables, the second section deals with the range of passenger behaviours, and the final section deals with interactions with rail personnel and emergency management.

This taxonomy provides the basic outline of human factors for long distance passenger train travel. This will provide the structured approach needed to

a) search the literature for relevant psychological and ergonomic research,

b) identify gaps in present knowledge about rail passenger car design, and

c) make specific design recommendations for new passenger cars.

1. GENERAL ENVIRONMENTAL VARIABLES
(These factors interact with the behavioural variables in section 2, below.)
- 1.1 Temperature
  - 1.1.1 Controls
  - 1.1.2 Delivery of warmer or cooler air
- 1.2 Air quality
  - 1.2.1 Humidity
  - 1.2.2 Pollutants
  - 1.2.3 Smells (olfactory stimuli)
  - 1.2.4 Circulation and exchange
- 1.3 Auditory stimuli
  - 1.3.1 Noise
  - 1.3.2 Loudspeaker message systems
  - 1.3.3 Music, masking and other input
  - 1.3.4 Transmission of conversation
  - 1.3.5 Interaction of activity and preferred noise level
- 1.4 Vibrations
  - 1.4.1 Frequencies
  - 1.4.2 Amplitudes
  - 1.4.3 Variability
  - 1.4.4 Localization
- 1.5 Accelerations (or g forces) and Moments, such as heave and pitch (up and down), sway and yaw (side to side), shunt and jerk (acceleration and deceleration)
  - 1.5.1 Frequency of occurrence
  - 1.5.2 Time related effects on tolerance
  - 1.5.3 Speed/comfort trade-offs
- 1.6 Lighting
  - 1.6.1 Maintenance and cleaning requirements
  - 1.6.2 Adjustability
  - 1.6.3 Variability of exterior light through windows
  - 1.6.4 Range of light levels (pools of light or darkness)
  - 1.6.5 Reflections
  - 1.6.6 Glare
  - 1.6.7 Positioning
  - 1.6.8 Colour mixture of artificial light and natural light through windows
- 1.7 Signs
  - 1.7.1 Placement
  - 1.7.2 Design (colours, character height, graphics, symbols, etc.)
  - 1.7.3 Lighting of signs
- 1.8 Other visual stimuli
  - 1.8.1 Sight and view lines from accommodation and public spaces
  - 1.8.2 Specially designed viewing (sightseeing) spaces
  - 1.8.3 Colour and decoration effects on mood, comfort, etc.
  - 1.8.4 Effects of mirrors and patterns on depth perception, "spaciousness"
- 1.9 Space
  - 1.9.1 Public spaces
    - 1.9.1.1 aisles
    - 1.9.1.2 lounges, restaurants, snack bars
    - 1.9.1.3 toilets, washrooms
    - 1.9.1.4 between cars, vestibules, etc.
  - 1.9.2 Accommodation spaces
    - 1.9.2.1 seating
    - 1.9.2.2 sleeping compartments

- 1.9.2.3 rooms and roomettes
- 1.9.2.4 materials and fabrics in accommodation spaces

2. BEHAVIOURAL VARIABLES

- 2.1 Boarding and leaving the train
    - 2.1.1 Finding the right door, signs
    - 2.1.2 Platforms, steps, handrails, doorway dimensions, etc.
- 2.2 Locating your "territory" on the train
    - 2.2.1 Seat and/or accommodation assignment
    - 2.2.2 Reconnaissance
    - 2.2.3 Changing seats or accommodation
- 2.3 Handling luggage
    - 2.3.1 Carrying luggage on the train and down the aisle
    - 2.3.2 Stowing luggage and bags
    - 2.3.3 Needs for access to bags
    - 2.3.4 Needs for security of bags
- 2.4 Activities in the accommodation space
    - 2.4.1 Sitting
        - 2.4.1.1 adjustability
        - 2.4.1.2 height
        - 2.4.1.3 cushioning
        - 2.4.1.4 covering
        - 2.4.1.5 arm rests
        - 2.4.1.6 orientation with regard to direction of travel
        - 2.4.1.7 ergonomics of design and contour
        - 2.4.1.8 sitting on other than a chair (eg. on a bed)
    - 2.4.2 Reclining
        - 2.4.2.1 in a reclining seat
        - 2.4.2.2 across more than one seat
        - 2.4.2.3 in a compartment
        - 2.4.2.4 in a roomette
        - 2.4.2.5 other places to recline
    - 2.4.3 Reading
        - 2.4.3.1 lighting and controls
        - 2.4.3.2 distracting stimuli (noise, adjacent passengers, etc.)
        - 2.4.3.3 train induced movement of the reading material
    - 2.4.4 Talking and social interactions
        - 2.4.4.1 with other members of the travel party
        - 2.4.4.2 with other nearby passengers
        - 2.4.4.3 with distant or passing persons
        - 2.4.4.4 with train personnel
        - 2.4.4.5 size and composition of travel group and conversation level
            - 2.4.4.5.1 patterns of social interactions in different groups
            - 2.4.4.5.2 speech volume required for different size social groups

- 2.4.5 Playing games
  - 2.4.5.1 playing surfaces (for card or board games)
  - 2.4.5.2 effects of vibrations and movement (eg. tilt)
  - 2.4.5.3 lighting
  - 2.4.5.4 games provided by the rail company (cards, portable video games, etc.)
- 2.4.6 Sightseeing (looking out the window)
  - 2.4.6.1 announcements for scenic views or points of interest
  - 2.4.6.2 ability of persons outside to see in
  - 2.4.6.3 cleanliness and clarity of windows
  - 2.4.6.4 tints, shades, curtains, etc.
  - 2.4.6.5 speed, distance and line of sight interactions
- 2.4.7 Working
  - 2.4.7.1 writing
    - 2.4.7.1.1 surface
    - 2.4.7.1.2 lighting
    - 2.4.7.1.3 vibrations and movements
  - 2.4.7.2 knitting, sewing, crafts
  - 2.4.7.3 other individual work
  - 2.4.7.4 work interactions in a travel group
- 2.4.8 Self care (space required, preferred location, baggage access)
  - 2.4.8.1 eating
  - 2.4.8.2 drinking
  - 2.4.8.3 grooming and hygiene (eg. washing, shaving)
  - 2.4.8.4 changing clothes
  - 2.4.8.5 unpacking/repacking personal effects
- 2.4.9 Care of travelers with special needs
  - 2.4.9.1 infant care
    - 2.4.9.1.1 feeding
    - 2.4.9.1.2 washing
    - 2.4.9.1.3 changing
    - 2.4.9.1.4 entertaining
    - 2.4.9.1.5 other
  - 2.4.9.2 child care
  - 2.4.9.3 care of an elderly or handicapped person by an attendant or companion
    - 2.4.9.3.1 types of care required
    - 2.4.9.3.2 special human factors problems (eg. getting 2 persons and 1 wheelchair into a washroom)
- 2.4.10 Sleeping
  - 2.4.10.1 possible sleeping positions in different accommodations
  - 2.4.10.2 orientation with regard to the direction of movement, sway, etc.
  - 2.4.10.3 environmental factors promoting or interfering with sleep
    - 2.4.10.3.1 height from floor, head clearance, etc.
    - 2.4.10.3.2 noise, vibrations, etc.
    - 2.4.10.3.3 time zone changes
    - 2.4.10.3.4 stops at intermediate stations
    - 2.4.10.3.5 firmness of sleeping surface
  - 2.4.10.4 lighting, temperature and privacy controls (eg. locks, shades, background music)
  - 2.4.10.5 behaviours characteristic of normal sleep (eg. bodily movements, dreams)
  - 2.4.10.6 behaviours of abnormal sleep

(eg. snoring, sleepwalking, enuresis)
2.4.10.7 travel groups and preferred sleeping arrangements
2.4.10.8 sharing accommodation with strangers
2.4.11 Intimate social behaviours (both positive and negative)
2.4.11.1 amount of space and privacy in different accommodations
2.4.11.2 sound damping and sound transmission in different accommodations
2.4.11.3 social facilitation/constraint of affectional behaviour
2.4.11.4 social facilitation/constraint of agonistic behaviour, arguments, etc.
2.4.12 Smoking
2.4.12.1 designated areas
2.4.12.2 ash trays
2.4.12.3 effects on other passengers
2.4.12.4 safety issues
2.5 Transitions between accommodation space and public space
2.5.1 Preparations (what to take, which way to go)
2.5.2 Checking to see if the space is clear
2.5.3 Movement into the space
2.6 Activities in common or public spaces
2.6.1 Aisles
2.6.1.1 walking
2.6.1.1.1 aisle width
2.6.1.1.2 passing other pedestrians in the aisle
2.6.1.1.3 effects of train accelerations on walking
2.6.1.1.4 walking surface
2.6.1.1.5 range of footwear (barefoot to high heels to slushy boots)
2.6.1.2 standing around, stretching, rearranging, etc.
2.6.1.3 playing (especially in the case of children)
2.6.1.4 exercise
2.6.1.4.1 exercises possible in the space available (eg. walking the aisles)
2.6.1.4.2 exercise area and/or equipment
2.6.2 Washrooms, toilets
2.6.2.1 signs
2.6.2.1.1 location
2.6.2.1.2 status (occupied vs empty)
2.6.2.1.3 operation (eg. how to lock the door, how to flush, when not to flush, etc.)
2.6.2.2 space and arrangement
2.6.2.2.1 door and entranceway
2.6.2.2.2 fixture sizes, heights, etc.
2.6.2.2.3 mirrors
2.6.2.3 operation of the door, lock, etc.
2.6.2.4 operation of fixtures (lights, sink, toilet, etc.)
2.6.2.5 location, type and disposal of toilet paper, towels, tissues, soap, etc.
2.6.2.6 using the toilet
2.6.2.7 washing
2.6.2.8 shaving
2.6.2.9 bathing
2.6.2.10 other uses of the washroom (eg. changing clothes if you only have a seat)

- 2.6.3 Lounges, snack bars and restaurants
    - 2.6.3.1 signs
    - 2.6.3.2 access
    - 2.6.3.3 seating
    - 2.6.3.4 service
    - 2.6.3.5 lighting
    - 2.6.3.6 views
    - 2.6.3.7 smoking areas and facilities
    - 2.6.3.8 self-serve vs waiter/waitress
    - 2.6.3.9 tables and coverings
    - 2.6.3.10 dishes, utensils, condiments
    - 2.6.3.11 nutritional and aesthetic properties of food and drink
    - 2.6.3.12 maintenance and cleaning
    - 2.6.3.13 take-out service and preferences for where to eat and drink
    - 2.6.3.14 special considerations regarding alcoholic beverages

2.7 General Psychological considerations

- 2.7.1 Regulation of human contact
    - 2.7.1.1 individual and social determinants of personal space
    - 2.7.1.2 determinants of positive contact
        - 2.7.1.2.1 caretaking
        - 2.7.1.2.2 affection, play, or intimate conversation
        - 2.7.1.2.3 thermo-regulation
    - 2.7.1.3 determinants of negative contact
        - 2.7.1.3.1 crowding in queues, pedestrian conflict in doorways, overlap of aisles and seating space, and other transient contacts
        - 2.7.1.3.2 aggressive interactions, fights, sexual harassment, etc.
        - 2.7.1.3.3 perceptions regarding other negative contacts, eg. spread of disease through indirect contact
    - 2.7.2 Relation between perceived cost of furnishings and "comfort"
    - 2.7.3 Relation between perceived cleanliness and "comfort"
    - 2.7.4 Perceived and actual safety
        - 2.7.4.1 overall rail travel safety and perceptions of safety
        - 2.7.4.2 safety of specific features or fixtures
        - 2.7.4.3 safety of specific behaviours
    - 2.7.5 Phobias, fears
    - 2.7.6 Stress reduction
    - 2.7.7 Entertainment, festivities
        - 2.7.7.1 provisions for passenger entertainment
        - 2.7.7.2 regulations, rules, and social sanctions concerning permissible entertainment (eg. dancing, gambling, loud singing, etc.)
    - 2.7.8 Special travel groups
        - 2.7.8.1 business or working travel parties
        - 2.7.8.2 special or festive occasion travel parties
        - 2.7.8.3 groups of children, students etc. with supervisors
        - 2.7.8.4 groups of sports fans
        - 2.7.8.5 travel groups requiring or preferring isolation
    - 2.7.9 Travelling with pets, valuable livestock, etc.

3. Interactions with rail personnel

- 3.1 Identifying help, information, or authority figures
    - 3.1.1 Care provided by the rail company for
        - 3.1.1.1 general travelling population

            - 3.1.1.2 mildly handicapped persons
            - 3.1.1.3 severely handicapped persons (with or without an attendant)
            - 3.1.1.4 unaccompanied children
        - 3.1.2 Means for finding/requesting information or assistance
- 3.2 Training and demeanor of staff
    - 3.2.1 Training in equipment, procedures and regulations
    - 3.2.2 Training in human relations
    - 3.2.3 Feedback mechanisms for praise or complaints
- 3.3 Emergency management
    - 3.3.1 Types and frequencies of emergencies
    - 3.3.2 Relevant emergency procedures
    - 3.3.3 Effects of "preventative" announcements

Human Factors for Passenger Rail Design
Literature Review

TABLE OF CONTENTS

INTRODUCTION 1

1. Environmental Variables 3

1.1 Temperature 3
1.2 Air Quality 6
1.3 Auditory Stimuli 8
1.4 Vibrations 13
1.5 Accelerations 15
1.6 Lighting 17
1.7 Signs 27
1.8 Other Visual Stimuli 31
1.9 Space 33
1.9.1 Public Spaces 33
1.9.2 Accommodation Spaces 36
1.9.2.1 Seating 36
1.9.2.2 Sleeping Compartments 39
1.9.2.3 Rooms and Roomettes 40
1.9.2.4 Materials and Fabrics in Accomodation Spaces 42

2. Behavioural Variables 47

2.1 Boarding and Leaving the Train 47
2.2 Locating Your "Territory" on the Train 48
2.3 Handling Luggage 51
2.4 Activities in the Accommodation Space 52
2.4.1 Sitting 52
2.4.2 Reclining 53
2.4.3 Reading 53
2.4.4 Talking and Social Interactions 56
2.4.5 Playing Games 57
2.4.6 Sightseeing (Looking Out the Window) 58
2.4.7 Working 59
2.4.8 Self Care 60
2.4.9 Care of Travelers with Special Needs 60
2.4.10 Sleeping 67
2.4.11 Intimate Social Behaviours 69
2.4.12 Smoking 69
2.5 Transitions Between Accommodation and Public Space .. 70
2.6 Activities in Common or Public Spaces 71
2.6.1 Aisles 71
2.6.2 Washrooms, Toilets 73
2.6.3 Lounges, Snack Bars and Restaurants 74
2.7 General Psychological Considerations 82
2.7.1 Regulation of Human Contact 83

2.7.2 Relation Between Perceived Cost of Furnishings and "Comfort..................... 85
2.7.3 Relation Between Perceived Cleanliness and "Comfort" 86
2.7.4 Perceived and Actual Safety 86
2.7.5 Phobias, Fears 89
2.7.6 Stress Reduction 89
2.7.7 Entertainment, Festivities 91
2.7.8 Special Travel Groups 91
2.7.9 Travelling With Pets, Valuable Livestock, Etc. 93

3. Interactions With Rail Personnel 94

3.1 Identifying Help, Information, or Authority Figures 94
3.2 Training and Demeanor of Staff 95
3.3 Emergency Management 98

Introduction

Modernization of VIA Rail's passenger fleet means that human factors can play a part in the development of new passenger coaches. The term "human factors" refers to the fit of people to environments, machines, and procedures. It includes such considerations as passenger perceptions of features, determinants of both positive and negative human contact, and service delivery, to name a few aspects. Ergonomics is generally thought of as a sub-set of human factors. It is the area of human factors dealing with physical space, access and comfort requirements.

The list of human factors which we have applied to rail travel is quite extensive. In a previous working document, Behavioural Team outlined the taxonomy of human factors considerations for long-distance train journeys.

A second working document listed several hundred recent articles dealing with relevant human factors issues. The present report is a review of the most applicable and recent of these studies and reports.

> For this report, we have summarized the latest available reports which might have been relevant to coach design. We emphasize "might" because, as it turns out, the net available information is markedly incomplete and fragmented. As such, the reader of this report is advised that the holes in coverage are profoundly large.
>
> The materials reviewed here are sometimes of only peripheral value to the project. However, we judged that it would be better to err on the side of inclusion than on exclusion.
>
> As a consequence, this report does not achieve the usual Behavioural Team standards for orderliness and relevance. It does accurately mirror the present fragmented knowledge published on the human factors of rail coach travel.

In trips lasting from six hours to six days, human factors touch on every aspect of daily living. The train serves as a sort of moving hotel that provides accommodations, services and diversions. Proper attention to the ergonomic and psychological needs of the passengers can make train travel more attractive to a variety of passengers.

A study which illustrates how transportation service attributes influence traveller's mode decisions was conducted by Mallen et al. (1976). It contains a list of the advantages and disadvantages of train travel compiled from a Canadian questionnaire answered by 40 women and 51 men.

Some of the advantages of train travel include the following:

--- The train is cool in the summer.

--- The passenger can relax and enjoy the scenery.
--- There is freedom to move around, the train is less restricting than the bus or car.
--- Business travelers can work.
--- Travellers have a high degree of confidence in the safety of the train in bad weather.

Some disadvantages of train travel are:

--- Travellers do not have confidence that the train will arrive on time.
--- There is a limited choice of arrival and departure times.
--- Temperature control seems to be inconsistent in the winter.
--- The sum of the fares for a family group or an adult group costs more than using the car.
--- Luggage problems beset the the train traveller - the train staff do not help and it is a struggle through the often crowded aisle.
--- The quality of food is sometimes inadequate, and the cost is too high.
--- It is not easy to work or read on the train because of the rocking and bumping, and the noise.
--- Guardians of younger children are bothered by the need to control their children who become bored on the longer trip.
--- Staff on the train are sometimes unfriendly, unhelpful, and do not take care to humanize the relationships with passengers.

These points emphasize the variety of human factors that determine comfort and satisfaction for train passengers. Whatever is most uncomfortable or dissatisfying takes on great importance in a long journey. Therefore, the physical environment, social situations and stimuli, opportunities for various necessary or pleasurable behaviours, and interactions with the train staff must all be satisfactory to make a trip a pleasant experience.

1. Environmental Variables

1.1 Temperature

OVERVIEW

In the past thirty years there has been a change-over from steam to electrical heating in rail passenger cars. As a consequence, the reliability of heating equipment has been considerably improved.

The move towards full air-conditioning of all main-line coaches has many advantages from the passenger environment point of view, but the reliability of equipment is still an issue. Therefore, simplification of controls and equipment is a continuous task of the design organization.

REVIEW OF THE RESEARCH

A comfort chart prepared by Bell and Watts for British Railways (No author, "Passenger comfort in urban transit vehicles - A state of the art report." 1976) assumes air speed within the vehicle to be 0.05 to 0.15 m/s (10 to 30 ft/min). Under these conditions, the ideal temperature within the vehicle for 80 percent of seated passengers in the winter ranges between 17 and 25 degrees celsius. The optimum temperature for 80 percent of seated passengers in the summer ranges between 19 and 26 degrees.

As the humidity increases from 30 to 60 percent, there is a compensatory temperature drop of about 2 degrees to give comparable thermal comfort.

It seems that these temperature ranges are too broad and that a narrower temperature range would offer more practical information about optimum conditions of thermostatic control. Individual preferences don't necessarily fit into neat models, however.

On the basis of other researchers' studies, Temming (1980) has compiled a graph to show the relationship between outside air temperatures and corresponding desirable interior air temperatures in passenger cars. Unfortunately, the author does not provide details of how passengers' subjective impressions of thermal comfort were gathered.

The optimal mean interior temperature falls gradually in a non-linear fashion from +28 degrees celsius to +22 degrees for outside air temperatures between -30 degrees to +10 degrees. For outside air temperatures between +10 and +40 degrees, the optimal mean air temperature climbs in a similar manner from +22 degrees to +26 degrees.

For maximum comfort, the author suggests that there should be a difference of air temperatures in the lower and the upper part of the passenger compartment (i.e.

foot space and head zone) with the difference becoming larger as the interior air temperature rises. For a mean interior air temperature of +20 degrees celsius, there should be a +4 degree difference in temperature between the foot and head zone. For an extreme interior air temperature of +40 degrees, there is optimally an 8 degree difference between the two zones.

Since higher temperatures in the foot zone are required, the heating air should preferably be introduced into the lower half of the occupant cell. Likewise, cool air should be introduced into the upper half of the occupant cell through appropriate vents.

Parker (1972) describes the ASHRAE chart, which is based on average American opinions. It consists of lines showing equal comfort over a range of relative humidity and dry bulb readings in conditions of constant air flow. Unfortunately, no mention is made of how the data was collected nor were the characteristics of the 'average American' specified. The author stresses that the optimum comfort conditions for the average person depend on the climatic conditions in that zone. This is why it is imperative for the engineer to take into account what is considered to be an acceptable temperature level in that part of the world where the equipment is required to function. Although the ambient temperature is purported to have a direct effect on what is considered to be a comfortable environment, it is encouraging to note that people readily adapt to new ambient conditions. No data is provided, however, to support this statement.

A heating chart described by the same author shows the design criteria and parameters that determine the total cooling and heating estimates.

According to Oborne (1978), the maintenance of thermal comfort over a period of time depends upon the existence of heat balance, the primary variables of which are:

- The internal heat production per unit body surface area
- Thermal resistance of the clothing
- Mean radiant temperature
- Pressure of water vapor in the ambient air
- Relative air velocity
- Mean skin temperature
- Heat loss per unit of body surface area by evaporation of sweat

Since some of these factors (e.g. clothing type and degree of passenger sweating) are outside the control of the designer, the primary variables of interest to the design engineer will be air temperature and humidity.

Temming and Hucho (1979) describe occupant cell ventilation requirements in passenger cars at warm summer temperatures. A number of experimentally derived curves show the relationship between thermal sensitivity at various air temperatures and air velocity. At higher temperatures, thermal sensitivity is held constant by an increase in the flow velocity. But this relationship between air temperature and air velocity does not apply for air-flow velocities beyond the range of approximately 2 to 2.5 m/s. These results demonstrate that a good ventilation system alone cannot replace air conditioning at hot summer temperatures.

The paper also examines design criteria and thermodynamic issues of how air jets may be directed primarily to those areas that objectively permit maximum body heat loss. Air jets may also be directed primarily to those areas of the occupant body surface that subjectively convey the most desirable cooling sensation. The isotach method (isotachs are lines in a given plane connecting points with equal air flow velocity) is a tool used for the investigation of air-flow conditions.

Six basic rules for thermal comfort by ventilation cooling are:

- The design of the ventilation system must permit the application of an air jet to the driver and each occupant.
- The axes of these air jets should not be fixed.
- The air jet should allow for precise adjustment.
- Standard target for ventilation jet axes is the chest region.
- A narrow air jet should have a flow velocity of up to roughly 3.0 m/s at the occupant body surface.
- There should be no effects that might cause unpleasant sensations. In general, desired occupant temperature in passenger cars is 22-25 degrees celsius in summer and 22-30 degrees celsius in winter.

One major criticism of this paper - like many others - is that it does not explain how subjective impressions of thermal sensitivities were obtained.

In a pressure ventilated vehicle, open windows can completely upset air flow conditions to the discomfort of all but a few passengers. However, pressured ventilation of coaches is the favored practice for optimal control and dust reduction. Consequently, opening-windows are not provided on new designs of rolling stock.

In the Advanced Passenger Train (APT) (Spring, 1972) air is circulated through each coach at a rate of 55 cubic meters/minute when the outside coach dry bulb temperature lies within the range 0 to 26 degrees celsius. Not less than two thirds of this air is fresh air. The quantity of fresh air may fall (approximately linearly) to a minimum of 25 cubic meters/min at extreme temperatures of -7.5 and 30 degrees celsius (dry bulb).

With outside temperatures up to 21 degrees celsius, the inside temperature in the seating area of the coach is set between 18 - 21 degrees; in the vestibules and toilets, between 15 - 18 degrees. For outside temperatures in the range of 21 - 23 degrees, neither heating nor cooling is in operation, and all the air circulated is fresh air.

With an outside temperature of 23 degrees, the inside temperature is 21 degrees. The inside temperature may rise linearly to 25 degrees as outside temperture rises to 30 degrees.

A general recommendation is that the air velocity in seated areas should not exceed 1 m/s. This figure is lower than the 3 m/s suggested by Temming an Hucho (1979) because it describes a large mass of moving air, not just a narrow jet.

Heino et al. (1979) make the following recommendations on the basis of studies which have exaninined heating and cooling systems of Finnish passenger cars:

- Heated air should be distributed with sufficient uniformity so that extreme temperature gradients can be avoided.

* Surface temperatures of windows should be higher in winter so that the discomfort caused by drafts radiating from windows could be eliminated. Especially the temperature of the side windows should be raised through the installation of two-pane glass with internal heating elements.
* In summer, cooling should be arranged with the aid of a ventilation system. The current procedure of opening the window for air causes drafts and increases the noise level in the car.

In constructing an air-conditioning system, a packaged aproach is being attempted by a number of mainly European railways. This approach has some advantages from the viewpoint of production and relatively easy maintenance. However, the package does present considerable difficulties to air-conditioning engineers. These difficulties stem from the restriction of the dimensions of the components, brought about by the constriction of the underframe when these packages are mounted beneath the floor.

CONCLUSIONS

Since air conditioners have a number of moving parts and electrical circuits, the design of air conditioning equipment must have reliability as a primary objective. Various studies provide some guidance for determining optimal thermal conditions. Different people have different thermal preferences, so some individual control of air temperature and/or velocity is in order.

1.2 Air Quality

OVERVIEW

All three variables, temperature, humidity, and ventilation influence passenger comfort and must be considered together.

One of the most important requirements is amount of fresh air and air movement that is used to ventilate a vehicle. Very low rates of air movement will provide a feeling of stuffiness and allow the acculmulation of food, smoke, and body odors. Very high rates create undesirable and uncomfortable drafts.

REVIEW OF THE RESEARCH

The American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) standards suggest that "air motion should not exceed 45 ft/min. (0.23 m/s) and shall not be less than 10 ft/min (0.06m/s) at any time" (Oborne, 1978).

Ventilation rates of 34 cubic meters/h (20 cubic ft./min) of fresh air per passenger at air circulation velocities of 0.08 to 0.20 m/s (16 to 39 ft/min) have been recommended for high speed transportation. The majority of vehicles also use the ventilation system to pressurize the interior to approxiamtely 50 Pa (0.2 in. of water). This prevents dust from entering the vehicle and thus maintains air quality.

Regardless of whether or not air conditioning is used, a ventilation system should be provided because:

1. The air conditioning system may fail during a long trip.
2. Vehicle power may be temporarily lost and a means should exist to provide air changes.
3. The temperature inside the car may be within a comfortable range for passengers and neither heating nor cooling is required.

A relative humidity of 30 to 60 percent is quite acceptable. Excessively high humidities are uncomfortable owing to the lack of body cooling through evaporation at high temperatures, and a sensation of coolness at low temperatures. Humidities below 15% may result in drying out of the eyes, nose and throat.

There is some empirical evidence to support the claim that persons generally feel more energetic and show improved psychomotor performance under negative ion conditions than under normal conditions (Tom et al., 1981). However, other studies indicate that negative air ions do not significantly affect all types of tasks or all types of psychological states. The literature, in general, supports the view that ions have a biological significance.

The mechanisms for their action are still obscure and the controversy as to whether negative and positive ions have different and opposite effects is still unresolved. Thus, caution should be exercised before a decision is made to install ion generators in rail passenger cars. At the present time, commercial varieties of ion generators may produce not only negative ions, which may be desirable, but also ozone, which may be undesirable.

The importance which railway operators attach to the alleviation of the effects of pressure transients is illustrated by British Railway's decision to aerodynamically seal the Advanced Passenger Train against external pressure fluctuations. Trains on the Shinkansen network are similarly sealed.

The use of flow restrictions is proposed as a method of eliminating some of the pressure changes which are a potential source of passenger discomfort in railway tunnels.

An adjustable restriction at the exit portal of a tunnel could be used to eliminate the nose-exit wavefront and also the reflection of the nose-entry wavefront. Additionally, a restriction at the tail of a train could eliminate the tail entry and tail-exit wavefronts. Geometrical blockages are the most sensible types of restriction at both these locations (Vardy, 1979).

CONCLUSIONS

It is clear from the research discussed in this section that careful attention to ventilation requirements is essential if passenger comfort is a primary goal. Ventilation is an important factor in temperature control, removal of odorants, and air quality.

1.3 Auditory Stimuli

OVERVIEW

Railway noise is important because there is some concern that it causes considerable annoyance to train passengers as well as others. However, railway noise is not loud enough to cause pain or ear damage and there is some evidence that it is less annoying than the noise of other modes such as road traffic and aircraft noise.

This section reviews studies on the causes of railway noise, noise problems created by Shinkansen trains of Japan, how railway noise can be abated, and experimental studies of reactions to railway noise.

REVIEW OF THE RESEARCH

Thirteen tests were conducted inside rail transit vehicles in 13 international cities by Solomon, Solomon, and Silian (1968). A standardized test procedure measured vibration and noise inside subway trains operating at controlled speeds on sections of straight level subway. Test speeds were limited to 15 and 30 mph. The relative average noise levels for trains at 30 mph were as follows:

	Phons		Phons
Philadelphia	103	New York	98
Chicago	98	Boston	97
Lisbon	97	London	93
Stockholm	92	Toronto	90
Paris	89	Hamburg	87
		Berlin	85

United States systems ranked loudest as a group. Noise and ride smoothness were considered the most important of the factors making up "ride comfort."

The major source of noise on trains is the interaction between the wheel and the rail. Noise is created by the impact of the wheels on irregularities of the rails. Vibrations are set up in the wheels and the rails and transmitted as noise, or are transmitted to the car and its interior, causing other components to vibrate.

The problem of internal noise can be solved by:

1. eliminating the source of the noise
2. introducing a barrier between the noise source and listener
3. absorbing as much of the noise as possible.

Toronto has the lowest noise measurement of the 9 international subways as station arrival noise is 87 db and at departure it is 87 db. The Toronto vehicles use almost no rubber insulation or acoustical body insulation. Its quietness is attributable to sound abosorbing material in tunnels and superior alignment.

A study by Ford reported in Solomon, Solomon, and Silien (1968) concluded that monorail type systems were only marginally quieter than two rail systems, and that noise from both could be quieted at the source. Steel wheel systems can be made quieter by:

1. the use of damped wheels
2. shrouding the wheels
3. placing absorbing baffles alongside the track
4. placing acoustic treatment between the rails.

Harris (1979) states that the major noise sources of rail system noise are wheel/rail noise and propulsion from railcars and locomotives. The average sound level for curve squeal on urban transit systems to a distance of 30 m. is 89 dB(A). Aerodynamic noise due to vehicle forward motion does not contribute to noise at speeds less than 240 km/h; at higher speeds it may be an important factor.

When the train runs on an elevated structure such as a railway bridge, the sound levels can be as much as 20 dB(A) greater than corresponding levels when the train runs on track at grade. Sound levels for intercity passenger trains range from 56-81 dB(A) at speeds up to 200 km/h. For intercity trains in the open, maximum sound levels between 60-70 dB(A) are obtained.

In the last few years, transportation noise and vibration have become a difficult problem in Japan (Ikeda and von Winterfeldt, 1982). The Shinkansen high speed super-express train has been one of the most citicized sources of noise. Noise levels at 25 metres off the track are about 85-90 dB(A) but can reach up to 110 dB(A).

Noise quality standards of 70-75 dB(A) were issued by the Environmental Agency of Japan in 1975 in response to complaints to the Shinkansen trains. For existing lines, measures of noise abatement consist of building sound barriers and sound proofing at the track. For planned lines, there are research efforts to improve rolling stock and track. However, it is recognized that speed reduction in highly populated areas is the simplest way of reducing noise levels; routing is another factor.

Besides wheel/rail noise, Stanworth (1983) identifies the following railway operations as producers of noise - trains' pass-by noise, locomotive noise, freight wheel noise, warning signal noise, marshalling yard noise, flange squeal on tight curves, maintenance machine noise, and tracking machinery warning horn noise. People affected by these types of noise include railway staff and train passengers.

Ten Wolde and van Ruiten (1983) claim that surface roughness of the wheel and rail is the main origin of rolling noise. Rail corrugation introduces a considerable increase of sound inside and outside a vehicle as compared with passing of the same vehicle on non-corrugated rail.

In "Rail Passenger Comfort" (1964), it is stated that insulating materials have been used to provide both thermal and sound insulation on railway vehicles. Early experience with a cellular paper insulation between the inner and outer coach panelling indicated the necessity for adequate physical properties to prevent the insultation breaking down due to coach movement and vibration. Lightweight cellular construction insulating materials are now in use and glass fibre insulation is produced in pads ready for securing to the inside of the panelling. Sprayed asbestos has been widely used for thermal and sound insultation. However, potential health hazards preclude its continued widespread use.

Despite the above evidence about the annoyance of railway noise, Fields and Walker (1982) report less annoyance from railway noise at higher noise levels (above at least 35 NNI and 65 Leq than from road traffic or aircraft noise, at high noise levels (74 Leq or 55 NNI) railway noise is estimated to be less annoying by the equivalent of 4-15 Leq for road traffic and 13-30 NNI for aircraft. There are two reasons to explain the differences in reaction to railway noise:

1. railway noise tends to be more regular and predictable in character than road traffic or aircraft noise and hence less annoying

2. people generally have positive attiudes toward railways.

The above reports consider railway noise in a practical and general sense. The following studies examine railway noise in an experimental way, with the inception of the study below which develops a model of passenger discomfort.

Dempsey and Leatherwood (1976) and Leatherwood, Dempsey, and Clevenson (1980) developed a generalized model for the estimation of passenger discomfort response to complex noise and vibration. Discomfort estimates are in the form of a single estimator measured along a ratio scale anchored at discomfort threshold.

The model has several important features that distinguish it from other models. First, the discomfort modelling is based upon the psychophysical functions relating human discomfort response to the physical stimuli that produce the response. Thus discomfort is modeled as a continuous function of the stimulus parameters. Second, the model is sensitive to changes in physical stimulus parameters such as vibration frequency, vibration acceleration level, noise octave and frequency, and noise level. Therefore the model is useful for determining ride comfort design tradeoffs and as a tool for comparative assessment of vehicle ride quality.

In a study by Clevenson (1976) thirteen passenger-subjects were asked to rate their comfort associated with noise and vibration during a one-hour flight on a NASA twin-jet airplane. A range of vibration and noise levels was obtained by varying the thrust, the forward speed, and the position of the landing gear and drag brakes. Respondents were asked to rate designated 1-minute segments of the flight for comfort.

For constant vibration level, good correlations were obtained between vibration comfort ratings and noise comfort ratings, vibration comfort ratings and noise levels, and noise comfort ratings and noise levels. Both noise comfort rating and vibration comfort rating had poor correlations with vibration level. Passenger-subjects were able to distinguish and rate the noise better than vibration.

Broadbent (1957) contends that reliable performance deficits appear at noise levels of 90 dB. Others (e.g., Kryter, 1970) feel that experimental data show no adverse effects of regular, anticipated noise on nonauditory mental or physical work performance or output. In some studies, relatively low levels of noise have even been shown to have a positive effect on task performance, depending on the motivational or arousal state of the person.

It is unlikely that the low noise levels measured on the Amtrak trains in the study by Wichansky (1979) would result in serious discomfort or interference with tasks such as reading, writing or playing games, compared to that caused by high amplitude vibration. Noise was not significantly correlated with any of twelve passenger activities except talking-listening, to which it was positively correlated.

Glass and Singer (1972) affirm that noise per se has minimally deleterious effects on mental and motor performance. While high intensity noise may produce initial autonomic reactivity, responses wane with repeated stimulation. Most task activities under conditions of noise show no performance deterioration. However, unpredictibility of noise stimulation and perceived lack of control over noise (e.g., the perception that one cannot escape from noise) produced performance decrements on complex mental and psychomotor tasks, whereas predictable noise and/or perceived control over noise defined conditions that did not result in such effects.

Physiological arousal will not occur to noises much below 60-65 dB(A). Beyond that level there are definite arousal effects, and at levels exceeding 130 dB(A) there is pain. The authors found that noise of high intensity produced more autonomic reaction than low intensity noise. After 23 minutes of exposure to about 9 seconds of noise per minute, adaptation is so thorough that subjects in neither the high intensity nor low intensity groups differed in reactivity from subjects in a no noise control group. The authors also found that more errors on menial tasks occur under unpredictable noise conditions than under predictable noise conditions. On trains, some noises are regular and predictable while others are not. Subjective reports of annoyance are greater when noise is intermittent and irregular rather than steady, and intermittent noise affects task performance more than does steady noise. Adverse aftereffects appear only when the noise has been unpredictable. Also, noise is found less irritating, distractig, and unpleasant if the ubject believes he has potential control over the noise - which is not true of rail passenger cars. Exposure to uncontrollable in contrast to controllable noise results in greater subsequent performance errrors on a proof-reading task. There is a reduction of these errors when a subject believes he has direct control over noise termination.

In a study of aircraft noise by Williams, Stevens and Klatt (1969), listeners were asked to rate various aircraft flyovers in terms of their acceptability in the home. Judgments were obtained of noise presented without speech and of noise presented simultaneously with speech. For a given noise level, little difference was observed between ratings obtained when speech was absent versus present. There was a deterioration in comprehension of verbal messages when the peak noise level of aircraft (as heard indoors) exceeded 86 PN dB, a level corresponding to a rating of "barely acceptable."

Fields and Walker (1982) compared annoyance in a railway noise survey with that in two road traffic and three aircraft surveys to determine whether responses to environmental noises were similar or source-specific. Railway noise was less annoying than other noises at any given high noise level. Railway noise annoyance increased less rapidly with increasing noise level. At high noise levels this gap in reactions averaged 10 dB but ranged from 4-20 db.

Yokoo and Sebayashi (1981) analyzed the relationship between thinking processes and chronic exposure to noise. Eleven year old children were given thinking problems in which a female teacher read a three-digit number at a contant level, after which the subjects had to write down each number in reverse order. Some problems were given with a background of railway noise at various levels and the results were analyzed to determine the effects of the presence of noise and chronic exposure to noise. School children who were used to noise were more affected in their thinking process by noise than other children. Some habituation to suppress studying activities, such as suspension of thinking or abandoning work, were formed in children who always did their thinking in a noisy environment.

Finally, Malone (1982) mentions that the new Chicago Transit Authority Board rail passenger cars have fibre glass insulation, which keeps the noise at a low level.

CONCLUSIONS

Noise has little deleterious effect on mental and motor performance. However, performance deficits on some tasks appear at noise levels of about 90 dB. Noise levels on long distance passenger trains are generally below this level and do not interfere with most activities.

The major source of railway noise is the interaction between the wheel and rail. This noise can be reduced by use of damped wheels, shrouding the wheels, and placing absorbent baffles alongside the track.

Passengers can have additional noise insulation in the structure of the cars. Such features have been incorporated extensively in the British Rail Mk-3 Sleeper (Hill and Garratt, 1982, reviewed in section 1.9.2.3, below).

The Shinkansen high speed train has been one of the most criticized sources of noise in Japan. Noise levels just off the track are about 85-90 dB (A) but can reach up to 110 dB (A). Noise quality standards of 70-75 dB (A) were issued by the Environmental Agency in Japan in 1975 in response to complaints to the Shinkansen trains.

Off-track noise was also the subject of much of the European and North American research uncovered in our computer literature search.

Despite the evidence about annoyance of railway noise, there is less annoyance from railway noise at high levels than from road traffic or aircraft noise. This is because railway noise is more regular and predictable than road traffic noise. It is less annoying for passengers as well as those near the tracks.

While noise does not seem to produce performance deficits under normal conditions, unpredictibility of noise and perceived lack of control over noise produce performance deteriorations on complex mental and psychomotor tasks. The railroad noises that are unpredictable and uncontrollable include signal noises, passenger noises, and changes in the traction sound due to grades, bridges, braking and curves. However, most long distance train passengers do not seem to spend much of their time in taxing and complex mental psychomotor tasks.

1.4 Vibrations

OVERVIEW

Vibration is a physical parameter that has a strong impact on passenger comfort. It is a fundamental feature of the basic vehicle structure, making it difficult and very expensive to change an 'uncomfortable' vehicle, once its basic layout has been decided. Therefore, basic information concerning the ways in which people are affected by different types of vibrations must be made available to determine the design criteria for new vehicles.

In rail passenger transportation, most vibrations are produced by the contact of the wheels with the rails. Other vibrations originate in the power system, or auxiliary motors, fans, generators, etc.

Most recent studies concerning the effect of vibration on comfort may be divided into two main groups. The first group are those carried out to determine comfort levels of different vibration stimuli. This group may be further divided into those studies conducted under laboratory conditions and those carried out in actual transportion vehicles under field conditions. The second group of papers are generally review papers which have attempted to draw together some of the existing information to produce criteria or standards for determining human reaction to vibration.

REVIEW OF THE RESEARCH

Laboratory experiments aimed at investigating the comfort characteristics of vibration stimuli have generally followed three experimental paradigms (Oborne, 1976).

The first methodology involves the presentation of separate stimuli (varying in frequency and amplitude) to each subject who is required to label the stimulus as 'weak,' 'intense,' etc. The second paradigm is the converse of the first. A descriptive label is presented to the subject who is required to adjust the vibration stimulus until the comfort level expressed by the label is reached. Thirdly, physiological measurements have been used to relate vibration to perceived comfort.

Griffin et al. (1982) report on a series of experiments aimed at predicting the relative discomfort of seated persons subjected to sinusoidal vibration. Stimuli were presented in three translational and three rotational axes from a supporting seat surface, three translational axes from a backrest, and three tranlational axes from a footrest. They provide an objective method and a model for predicting the relative discomfort due to many complex (i.e. multi-frequency, random, impulsive, multi-axis, multi-input) vibration conditions to which passengers are exposed. The procedures may also be used to indicate the components of vibration responsible for discomfort and so aid designers to reduce discomfort.

The authors suggest that their procedures be evaluated in field studies. Meanwhile, there are several areas in which additional research is required to improve the procedures. Further clarification is required concerning the influence of relative motion between the seat, backrest, and footrest at low frequencies. The equivalent comfort contours should then be redetermined at the low frequencies and extended to lower frequencies. More comprehensive study of the assessment of complex motions (particularly multiple input and impulsive motions) is also desirable.

Oborne (1978) argues that despite the fact that many variables in a field study are outside the control of the investigator, naturalistic field studies of passenger comfort may offer more valid information to the design engineer than do studies carried out under laboratory conditions. The justification lies in the observation that subjects are employed (and sometimes paid) to carry out a specific task. Passengers on the other hand, are not employed (in fact they pay) and expect to receive a reasonable journey. On the other hand, it must be pointed out that laboratory studies do offer the investigator more control both over the type of stimuli to be applied to subjects, and the type of subjects employed.

Little agreement exists between various investigators as to which levels differentiate 'comfortable' from 'uncomfortable' levels of vibration (Oborne, 1978). This has come about as a consequence of investigators applying different semantic labels to the same vibrational stimuli. The recent trend has been to investigate human reaction to vibrations simply in terms of equal sensation curves without reference to any one particular comfort level. The curves demonstrate, as a function of frequency, the levels of vibration intensity which produce an equivalent 'sensation'.

CONCLUSIONS

The International Organization for Standardization (No author, "Guide for the evaluation of human exposure to whole-body vibration." 1978) provides a useful starting point from which designers may begin to decide appropriate vibration levels. The document refers, primarily, to whole-body vibration applied to seated or standing men. It provisionally applies to recumbent or reclining men but not to local vibration. Further, it covers only people in "normal health." Finally, and this restriction holds true for all composite curves, large individual differences exist in reaction to vibration. Curves depicting average reaction may mask these differences.

It should be noted that many of the laboratory and field studies have measured subjects' reactions to vibrational input over a one to four hour period. There has been little attention paid to the impact which longer exposure to vibrational input has on human comfort and performance.

1.5 Accelerations

OVERVIEW

Since the early days of mechanized mass transportation, much attention has been paid to establishing permissible acceleration (and deceleration) of vehicles for comfort and safety. Most of these results have been obtained by exposing a group of passengers to various acceleration loadings and by asking them to evaluate subjectively the sensation created.

REVIEW OF THE RESEARCH

Acceleration loadings can be classified into several categories, such as perceptible, noticeable, slightly uncomfortable, and uncomfortable. From these data, an allowable limit for ordinary operation has traditionally been chosen with the criterion that no discomfort would be felt by the great majority (e.g., 90%) of the passengers (Li, 1972). Allowable limits for emergency braking are also chosen such that the great majority of passengers would only experience slight discomfort. An important general finding is that discomfort depends not only on the magnitude of the acceleration but also on the rate of acceleration (jerk). Thus, an acceleration, of 0.15g, may or may not cause discomfort to a person depending on how fast this acceleration is attained (Li, 1972).

While data from subjective evaluations do provide statistically consistent thresholds of perception, they must be used with care. The reaction of the same person to the same acceleration loading may vary from time to time, and from one situation to another. A sensation quite acceptable to a person in a public transit vehicle, because s/he expects a lower ride quality, may be considered objectionable in an inter-city train.

There are at least two approaches to alleviate discomfort due to acceleration. An engineering approach in this connection is to devise a control which limits the acceleration and jerk during ordinary operation, but can also meet emergency situations. Another approach is through a more fundamental study of the mechanisms that cause discomfort or dissatisfaction.

An acceleration loading is equivalent to a force per unit mass applied to the body or an internal organ, and may therefore cause physical pain. Discomfort may be experienced as a mild form of motion sickness due to vestibular stimulation by the acceleration. This is more common on other modes of transportation, particularly by air and sea. A jerk is equivalent to a force applied at a high rate which is objectionable because of its suddenness which causes alarm and tightening of the muscles (in bracing oneself). This in turn leads to irritation and fatigue.

There is disagreement in the literature over the issue of whether human judgments of vehicle or ride comfort depend on time. The ISO (No author, "Guide for the evaluation of human exposure to whole-body vibration." 1978) argue that comfort will decline as a function of time in a motion environment. Richards (1978) questions these conclusions, criticizing the data on which the ISO standard was based. He suggests that comfort ratings reflect the particular motion inputs and do not merely reflect the time parameters of the ride.

Clearly, laboratory studies to ascertain the nature and parameters of a possible time dependence for comfort reactions are in order. Such studies will require better controls than those existing in the literature.

Some questions and observations need to be considered in the design of experiments on time dependence:

(1) Are time dependence effects (when found) the result of motion per se or of other factors correlated with it; i.e., time in a seat or fixed position? Control groups are needed to rule out a variety of alternative explanations of time dependence effects. Such control groups are rarely mentioned in the literature.

(2) How is time dependence related to (a) the regularity of the motion input and (b) the dimensionality of the motion input?

(3) Time dependence effects need to be distinguished from context effects. A motion may be rated differently in the context of a set of good motions than in a set of bad ones: such effects must be eliminated or controlled to assess for time dependence.

(4) The effect of the active or passive role of the rider has not been adequately investigated. Pilots are so often busy during a flight that they fail to notice how rough the ride is. Similarly, the driver in a car is often less aware of vehicle motion than passengers.*

(5) The problem of whether or not the individual is involved in self-initiated bodily movement is also not controlled in most studies. The interaction of self-initiated and passive movement has not been intensively studied.

Surely there are extremes of motion which do show time dependence because they lead to motion sickness or physical pain and/or physiological damage. There are also motions sufficiently mild that they cannot produce differential effects over time. The interesting subjective reactions are those that occur to motions between these two extremes.

On the topic of information integration over time, in general later judgments in a series are more highly correlated with overall trip comfort ratings than are earlier judgments. However, if there are a few bad motion segments in a set of better ones, passengers seem to ignore their presence in evaluating the total trip.

---

*Behavioural Team once suggested that bus drivers have hard seats so that

CONCLUSIONS

Two important hypotheses clearly require further investigation. It is possible that time dependence effects occur only at high motion levels; more research is needed to determine those levels for each degree of freedom of motion and for various interactions. A second possibility is that people differ in their reactions to motion; some people may show time dependence, while others do not. Whether such individual differences exist, and what other factors relate to them, needs to be determined.

1.6 Lighting

OVERVIEW

Lighting influences the comfort of persons occupying a space such as a passenger railway coach and their subjective impressions of that space. The following section includes criteria for good lighting design, and analysis of lighting trends over the next twenty years, suggestions for lighting in long distance railway cars, a number of experimental studies of lighting, and the use of the "semantic differential" (a multidimensional scaling procedure) to measure subjective impressions of lighting in a space. Some key lighting design criteria are included.

REVIEW OF THE RESEARCH

In an unpublished paper by A. Rosenfeld entitled "Lighting," it is stated that the criteria for a good lighting design include:

1. All spaces (entry, transitional areas, work spaces, exits) are properly composed in a clear hierarchy of importance.
2. Lighting provides spatial clarity.
3. Light is cost effective.
4. The quantity of lighting is appropriate for work type, and so enhances comfort, safety, and productivity.
5. The lighting has fully utilized the potential of daylight, if available.
6. It is energy effective.

For the luminous environment to be visually comfortable, there should not be any glare. Relative to the luminaire, the direct glare zone (heads-up task) is 45-90 degrees and the indirect glare zone (heads-down task) is from 0-45 degrees. Thus in trains, where most activities (reading, writing) are heads down, lighting for a task should not be placed in the 0-45 degree position as it will produce glare and decrease comfort and visibility.

In order to be visible, each critical detail of the task must differ from its background in brightness texture or colour. Optimum comfort is achieved when the task zone is slightly lighter than the surrounding surfaces. The general area should be five times as bright. In areas surrounding the task location, illumination levels should be one-third the level of the task area and no lower than 22 footcandles (fc).

Since the sun moves south in the winter, a southern orientation of windows would allow maximum daylight and solar heat during those months. Since most coach cars have windows and seats on both sides, this is not an issue. In sleeping cars, lounge cars and other non-symmetric arrangements the direction of the windows on East-West runs may be important.

Light colour changes with the time of day, cleanliness of the atmosphere, and reflection of the surrounding objects, with 7400 K being the colour temperature of preferred daylight. Daylight can reduce the need for artificial illumination by working in combination with it.

Windows help in optimizing daylight as well as providing a view out. The standard norm of building window area is 1/5 - 2/5 of the walled areas. Windows in commercial airliners are usually small (about 10% of the wall area) and placed below the line of sight for viewing the ground. Windows in trains and buses are much larger.

Glare is one of the major difficulties with windows, but can be controlled through blinds or curtains. Both blinds and curtains should be provided in roomettes. Privacy is desirable at times when you want to let daylight in and at other times when you want to shut daylight out.

The proper illumination, contrast, and reflectance levels suggested for some areas of offices are as follows:

Insert Table 1 Here

TABLE 1 Some recommended surface reflectances

Area	Surface	Range of reflectance %'s IES		PWC
Offices	ceilings	80-90		82-92
	walls	40-60		50-80
	furnishings	25-45	blinds	50-60
	floors	25-45	desk tops	25-45
			furniture	25-45
General	ceilings	70-90		
	walls	40-60	business machines	25-45
	furnishings	25-45	floors	20-40
	floors	20-50		
Industry	ceilings	80-90		
	walls	40-90		
	equipment & desk tops	25-45		
	floors	20 +		

Some Average Contrast Ratios

		Desirable		Min. Acceptable	
Area	Zone	Low	High	Low	High
Offices	2	1/3	equal		
	3	1/5	5x		
General	2	1/3	equal	1/5	5x
	3	1/5	5x	1/10	10x
Industry	2	1/3	3x	1/5	5x
	3	1/10	10x	1/20	20x

Some illumination levels

Area		Footcandles on Task IES	PWC(1978)
Assembly	easy	30	
	medium	100	
	extra fine	1,000	
Banks	lobby general	50	
	tellers station	150	
Hospital	emergency		
	operations local	2,000	
	examining room	100	
Offices	drafting	200	215
	reading - poor contrast	100	80
	reading - high contrast	30	54
	corridors	20	11
	cafeteria (quick service)	50	32
Residences	dining	15	
	ironing	50	
	reading	30	

Lighting levels in rail passenger compartments do not need to be as high as in a work setting. When a passenger does wish to read or work, sufficient light should be available. But this should be individual task lighting that does not impinge on other passengers.

In a theoretical review of lighting trends over the next twenty years, Ball and Mathias (1980) state that the lack of energy and high energy cost will result in less energy available for lighting. There will be more government regulations - for example, each facility will be allocated a certain number of BTU/sq.ft./yr. based on its use of lighting and geographical location. Also, fixture certification will be required, e.g., performance standards will have to be proven and labelled on fixtures. Non-uniform or task/ambient light will be the norm. Lighting control systems will be required so as to limit the quantity of light; such controls will be manual and proximity on/off switches. The use of natural light in combination with artificial light with a dimming switch to keep a constant light level will be required. Less light than that now used will be enough for most tasks.

Life cycle costing - deciding on lighting systems based on the total cost over the life of the system - will be commonplace. Centralized energy control via computers will also be common. The progressive lamp/fixture producer will sell a full-line lighting system. He will provide the total lamp/fixture/control package.

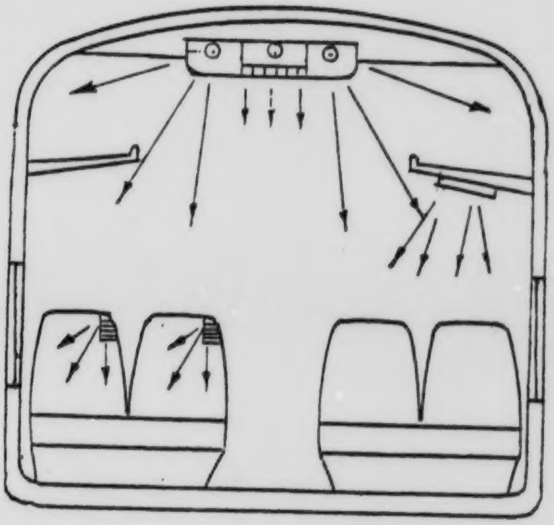
Lamp technology will progress - high efficiency fluorescents will be available, making it a leading lamp because of its linear course and good colour rendition. An improved high pressure sodium lamp will increase in popularity because it will be "colour improved" and the restrike problem ("instant-on") will be solved. Also, lower wattages without loss in efficiency will be available. This will permit installation in lower level ceilings such as on trains. Lower wattage bulbs will solve the problem of intense glare found with high wattages. This will allow closer spacing for good light distribution.

The 1990's are likely to bring a new lamp closer to the efficacy of white light of 300 lumins/watt. Improvements in fixtures will be made - many fixtures will be relocatable and easily moved from one area to another. Fixtures will be designed for better light distribution so lower wattage lamps can be used. Solid-state electronics technology will be introduced. Solid-state ballasts will give lower power losses and allow high frequency generation for higher lamp efficiency.

Higher voltage (600v) and high frequency lighting will be introduced by 1985. Fixtures will be lighter weight, easily movable with plug-in wiring, and will require less maintenance than present fixtures due to improved design that will reduce dirt accumulation. The use of fluorescent lamps will continue but they will have greater efficiency. Finally, natural lighting will be much more commonly used.

Wotton (1983) produced some notes on lighting in long-distance railway passenger cars for Behavioural Team. He states that two lighting environments - daytime and nighttime - must be provided in a long-distance railway car. For daytime, general lighting is to be used to make the whole car pleasantly bright. Local lighting may also be used by individual passengers to supplement general lighting and to allow them to read. The general lighting, controlled by train crew, is reduced at night to allow passengers to sleep. The aim of lighting for both daytime and

FIGURE 1



DAYTIME ENVIRONMENT

LOW BRIGHTNESS FLUORESCENT LUMINAIRE DOWN CENTRE OF COACH + 2 ROWS OF HIGHER BRIGHTNESS FLUORESCENT CEILING LUMINAIRES.

NIGHT-TIME ENVIRONMENT

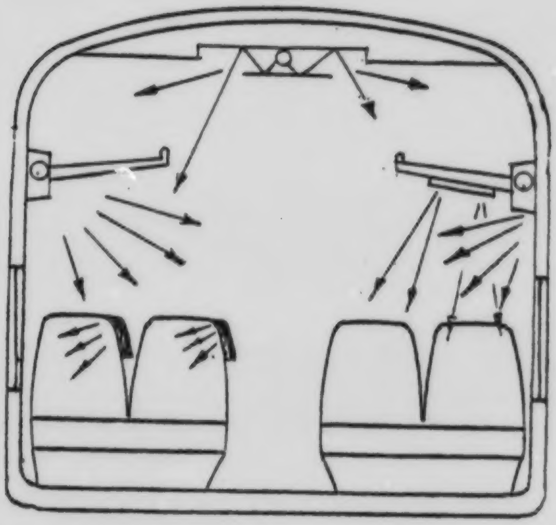
LOW BRIGHTNESS FLUORESCENT LUMINAIRE DOWN CENTRE OF COACH.

LOCAL LIGHTING

LEFT HAND SIDE: FLUORESCENT LUMINAIRE ON BACK OF EACH CHAIR.

RIGHT HAND SIDE: INDIVIDUAL INCANDESCENT LUMINAIRES IN EACH LUGGAGE RACK.

FIGURE 2



DAYTIME ENVIRONMENT

FLUORESCENT LOW BRIGHTNESS LUMINAIRE DOWN CENTRE OF COACH + FLUORESCENT LUMINAIRES AT BACK OF EACH LUGGAGE RACK.

NIGHT-TIME ENVIRONMENT

FLUORESCENT LOW BRIGHTNESS LUMINAIRE DOWN CENTRE OF COACH.

LOCAL LIGHTING

LEFT HAND SIDE: "EAR" WITH FLUORESCENT LUMINAIRE ON EACH CHAIR.

RIGHT HAND SIDE: INDIVIDUAL INCANDESCENT LUMINAIRES IN LUGGAGE RACKS.

nighttime is to allow movement in the aisle, allow obstructions to be seen, allow seat numbers to be read, and luggage to be placed on racks.

The brighter general daytime lighting might be provided:

1. by means of a continuous row of fluorescent luminaires concealed by the luggage rack on each side of the car. Some light is reflected from the car ceiling and some falls on the seats.

2. by means of a continuous row(s) of fluorescent luminaires down the centre of the coach.

Local lighting could be provided for each individual seat by a luminaire mounted in the "ears" of the seat. Alternatively, local lighting could be provided by luminaires in the luggage racks. Incandescent lamps will have to be used since the larger size of fluorescent lamps will not make adequate light control possible.

A general illuminance of about 15 fc (160 lux) should be provided for daytime and about 4 fc (45 lux) for nighttime. An illuminance of about 20 fc (220 lux) should be provided by local lighting for reading. It should be noted that these levels are lower than those suggested by others. The trends during energy-rich times were to make it bright everywhere, but dimmer, more localized lights are both efficient and pleasant.

Fluorescent lamps of a good colour rendering are required. Lamps of a "warm" colour are most suitable. Also, one-inch diameter fluorescent lamps should be used. These will probably eventually replace the present one and one-half inch diameter lamps.

Fluorescent lamps operate most satisfactorily on AC power supplies. A railway car will generate its own AC, allowing high frequencies to be generated. They will usually be in the 400 hertz to 25 kilohertz range.

The luminaires should be light in weight in relation with their need to be robust, easily installed, and easily maintained.

Insert Figures 1 and 2 Here

Boyce (1981) states that one of the principal functions of lighting is to enable work to be done quickly, accurately, and easily by making details easier to see and colours easier to discriminate without distraction or discomfort. In addition, good lighting is an aid to productivity. Lighting affects work, but the question is to identify the range of lighting conditions that allow improvement in work output to occur. On trains, this involves both the passenger who wants to read or write, and the train crew including the driver, who go about their duties.

In a laboratory study also reported by Boyce (1981), a group of people had to sort screws into different classes, or to crochet stoles for two-hour periods under different illuminances. There was an increase in output as illumination on the task increased from 100 to 300 to 700 to 1700 lx. The error scores decreased, as expected, with increased illumination for the crocheting but not for the screw sorting task. Here the error scores decreased as illumination increased from 100 to 300 to 700 lx but increased as the illumination went up to 1700 lx. In another study, using two simulated inspection tasks, better output was found with fluorescent lighting than with incandescent lighting.

In conclusion, the effect of increasing luminance on the performance of tasks follows a law of diminishing returns, i.e., equal increments in illumination produce less and less improvement in task performance until performance finally saturates. The illumination at which performance saturates depends on the visual difficulty of the task, which can be classified by the size and contrast of the critical detail. The smaller the size and contrast, the higher is the illumination at which task performance saturates. However, it is not possible to make a visually difficult task be performed as well as a visually easy task simply by increasing the illumination.

A study by Tinker reported in Boyce (1981) on the effect of lighting on the ease of reading found there is little improvement above 30 - 100 lx. Boyce concludes that the actual values chosen for the illumination necessary for reading are a matter of judgment, involving the form of the material to be read, the level and ease of reading required, duration of the work involved, and the age of the readers.

Insert Table 2 Here

TABLE 2

Minimum Recommended Levels of Illumination for Performance of Various Tasks (Kaufman, 1972)

Task	Corresponding Passenger Activity	Illumination Level (fc)
Conversation, Relaxation, Entertainment	Talking-Listening Doing Nothing Sleeping Smoking	10
Dining	Eating Drinking	15
Table Games	Games	30
Handcrafts	Handcrafts	70
Reading and Writing	Reading Writing	30 - 70*
[Using] Corridors	Walking in Aisles (Other)	20

* Varies depending upon content of written material, contrast level of printed matter, etc.

One possible implication of this research involves train personnel reading tickets of passengers who board at night. If the coach light levels are low, for the sake of sleeping passengers, critical features on the ticket should be large, clear and high contrast.

Lighting can be effective in influencing the impression given by the spaces used for a wide range of activities. Studies of impressions formed by lighting have used a correlation method whereby a subjective judgment of the lighting is related to a physical description of the lighting. The ultimate criticism of the method is that it starts from the lighting end of the question, not the people end. Questions, posed in terms of lighting, are asked of people. This is of little use if the aim is to discover how lighting affects people's impressions of a space.

In a multidimensional study (Flynn, reported in Boyce 1981), 96 observers experienced a conference room lit in six different ways. Observers' responses regarding impressions of the room were collected on rating scales. Factor analysis was then performed on the data. The five dimensions found were: evaluative, perceptual clarity, spatial complexity, spaciousness, and formality.

Another study (Flynn, reported in Boyce 1981) used an auditorium which was assessed by two different groups of people. The first group saw seven lighting conditions and recorded their impressions on thirteen rating scales. The second group saw thirteen lighting conditions and used a questionnaire with fifteen rating scales. The results for the five installations seen by both groups are recorded on five representative rating scales: clear/hazy, public/private, unpleasant/pleasant, spacious/cramped, simple/complex. The two groups of people showed consistency in their placing of the installations on each scale. The features of the lighting important for each scale are: high illuminations are related to greater clarity; low illuminations from incandescent sources and peripheral lighting are related to an impression of privacy; peripheral lighting and low illuminations produce a pleasant impression; the use of high illuminations and peripheral lighting is related to spaciousness; general lighting with wall washing leads to an impression of complexity.

The impression created by lighting can also influence what people do. To study this question, the experimenter uses simple covert observation and recording. One study (Taylor and Sucor, reported in Boyce, 1981) found that the most brightly lit passage was the one used by most people. La Guisa and Perney (reported in Boyce 1981) observed the duration of the attention which school children paid to a display card when it was the same luminance as the rest of the room and when the luminance was much higher. They found the duration of attention was much greater for the highlighted card.

Sanders et al. (reported in Boyce, 1981) measured the effect of illumination and light distribution on the noise produced by groups of people talking while waiting in an assembly room. They found that low, uneven illumination was associated with less noise than a higher, more even illumination pattern.

Cockram, Collings and Langdon (1981) did a study in a new building to determine the fluorescent lamp colours preferred for supplementing daylight and providing night-time lighting. Four of the offices were glazed with clear glass and four with tinted "anti-sun glass." The offices had different illumination levels. It was concluded that, for supplementing natural daylight, the daylight (CCT4300K) lamp is best because of its compatibility with daylight and its high luminous efficiency. This lamp was also well-accepted for night-time lighting.

Krtilova and Matousek (1981) argue that light of the quantity and spectral composition of daylight must be maintained. In particular, a suitable brightness contrast in the visual field and uniformity of the illumination must be maintained. Spectral composition of artificial lighting should be as close as possible to daylight and its colour rendering should also be good. White fluorescent lamps present the most frequently used type of lighting today.

Lemons and Robinson (1981) did an experimental test to study the relation of light levels, colour rendering index (CRI), and colour temperature. The experimental set-up consisted of a variety of 40-watt fluorescent lamps and two colour boxes with a fluorescent lamp strip fixture, controlled by reversible motors. Maximum performance occurred betwen 3300 and 4300K for both standard black and white and coloured tasks. Warm sources with a low CRI have an advantage over cool sources with a low CRI.

Prince (1981) states that the aim in office lighting, as in all good lighting (including on trains), is to enhance the pattern of light, shade, colour, and contour so that important objects can be seen while objects of minimal importance are downplayed. The work area should be illuminated to a level three times greater than that of the general surroundings. For general office lighting, fluorescent lamps are still considered the most practical type of lighting.

Chaikin, Derlega, and Miller (1981) conducted a study of the effect of room environment on self disclosure in a counselling session. Intimacy of self-disclosure was significantly greater in a warm, intimate room (pictures on the wall, soft cushioned furniture, rug, soft lighting) than in a "cold," nonintimate room (bare cement, block walls, overhead fluorescent lights).

Lighting affects work performance by increasing concentration. A paper (no author, "Criteria for the lighting of printing plans: special light for the working areas." 1981) points out that experiments have shown that a well-lit area helps concentration and attention and cuts down on tiredness and accidents. For rooms up to 5 metres in height it is suggested that fluorescent lights are most suitable. For very high rooms, halogen metal vapour lamps are best.

In a theoretical paper on lighting and health (No author, "Could fluorescent lighting be harmful to your health?" 1981) it is argued that glaring fluorescent lights may be causing workers nausea, headaches, eyestrain, and also resulting in absenteeism. Some scientists say that fluorescents may be directly related to bone disease, tooth decay, eye problems, and emotional depression. However, these claims have not been scientifically proven. The reason for this opinion is that fluorescents are moving away from the natural solar spectrum. Human beings need this natural sunlight to produce adequate amounts of Vitamin D. Critics of fluorescent light believe that it is the glare caused from poor lighting installations that is the problem.

Flynn and his associates conducted several studies using the semantic differential and multidimensional scaling techniques to measure subjective impressions of lighting of spaces. In a study by Flynn, Spencer, Martyniuk, and Hendrick (1973), subjects judged six types of lighting in an experimental room. Data from comparative ratings of all six lighting arrangements were in good general agreement with the initial ratings of the room. These tests suggest that lighting variables do produce consistent and shared impressions for users. Intensity of light emission from overhead lighting systems may affect the impression of "general clarity," while higher brightness levels produce an impression of increased "spaciousness." Wall lighting creates a favourable attitude about the space in "evaluative impressions," "spaciousness," and "perceptual clarity."

Multidimensional scaling provided three resultant factors in a three dimensional space: overhead-peripheral, uniform-nonuniform, and bright-dim.

In a continuation of research in the last study, Hendrick, Martyniuk, Spencer and Flynn (1977) used slides of six real spaces to simulate lighting conditions and measured reactions through the use of semantic differential scales. Comparative judgments were made between the slides and the real space. Six factors were extracted: evaluative, perceptual clarity, spaciousness, spatial complexity, formality, and perceived horizontality.

The first type of lighting portrayed was overhead downlighting of low intensity. The slide was rated as more pleasant, liked and interesting than the real space. Results for the second lighting type, peripheral wall lighting, were that the slide was congruent to the real space on the evaluative, spaciousness, and horizontality factors. For the third lighting type, overhead diffuse, low setting, the slide was perceived as not quite so perceptually clear as the real space. For overhead downlighting on end walls, the fit between slides and the real space was good for all six factors. For overhead diffuse, high intensity lighting, the room created a moderately negative evaluative impression, while the slide created a neutral impression. For the sixth type of lighting, overhead downlighting and peripheral and overhead diffuse, the fit between room and slide was good.

The above results offer the hope that reliable judgments of a visual space need not be "stimulus bound" by that space. Abstract dimensions of visual judgment can be tapped in the same way by a two-dimensional representation of that space. The semantic diferential provides an adequate description of impressions of a space. Ultimately such subjective judgments should be useful for design decisions. However, multidimensional scaling does not provide an adequate substitute for scaling of the real space.

Flynn et al (1979) argue that as the designer changes lighting modes (i.e., patterns of light or shade), he changes the compostion and relative strength of visual signals. This, in turn, alters impressions of meaning for the room user. The semantic differential and multidimensional scaling are two methods used to study subjective impressions to lighting.

The following rating scales have been found to differentiate between lighting systems in measuring subjective impressions: scales representing visual clarity, spaciousness, evaluation, relaxation, social prominence or anonymity, complexity, modifying influences, and spatial modifiers.

CONCLUSIONS

On trains where passengers want to read and write, the direct glare zone relative to the luminaire is 45 degres - 90 degrees and the indirect is from 0 - 45 degrees. On trains where most passenger activities are heads down, light for a task should not be placed in the 0 - 45 degrees as it will increase the production of glare and discomfort. Optimum brightness should be provided for tasks such as reading. In areas surrounding a task, illumination should be lower.

In the future lighting will be computer controlled. High efficiency flourescent lights will be one of the lamp leaders and a high pressure sodium lamp will increase in popularity. Higher voltage (600 V) and high frequncy lighting will make inroads by 1985.

Trains should have general lighting (fluorescent luminaires) down the centre of the coach or on the luggage racks, as well as local lighting controlled by passengers to enable them to read. A general illumination of 15 fc (160 lux) should be provided for daytime and 4 fc (45 lux) for the night-time. An illumination of 20 fc (220 lux) should be provided by local lighting for reading.

The effect of increasing lighting on the performance of tasks follows a law of diminishing returns. The smaller the size and contrast of the visual difficulty of the task, the higher is the illumination at which task performance saturates. For example, the ease of reading does not increase above 30 - 100 lx. Fluorescent lighting may be optimum for reading and writing tasks by passengers in trains.

The semantic differential, and to a lesser degree multidimensional scaling, are good techniques to measure the subjective impressions to lighting of a space. People are even able to provide reliable comparisons of lighting based on slides or pictures. This would make it easier to do provisional tests of lighting plans.

1.7 Signs

OVERVIEW

Most of the needs for information and orientation signs are in the train station. The complicated information about train schedules and stops, and directions to ticket counters, platforms, information, lost and found, washrooms, local transit, etc. need to be clearly displayed. There are fewer options on the train itself, and there are usually only two directions to go, toward the front or toward the rear.

Instructional or operational signs are more important on the train, however. An example is the famous "Please Do Not Flush The Toilet While The Train Is In The Station" sign. The passenger is in a relatively novel environment, with unfamiliar devices such as reclining seats and light dimmers. Without proper signs, some passengers may not even be aware of some of the equipment intended for their use.

REVIEW OF THE RESEARCH

A recent article by Beadle (1982) describes some of the developments in information systems and displays in train stations. Centralized computer control and various forms of dot matrix display are replacing the old manual flapboard signs. Most of the information on these systems would not be of particular interest to a passenger who is already on a train.

Passengers usually want information concerning their own train, not the whole system. Some information about connections might be useful, though. An on-board information display system could provide a variety of information. It could be used in combination with a public address system to announce upcoming stops, points of interest along the way, emergency information, or schedule updates.

Including a flexible visual display has several advantages over a public address system by itself. The PA system may malfunction, and information will be missed by those with hearing problems or by people who are talking when the announcement comes on. A visual display can remain on and even be updated automatically. For example, the basic message on the display could be something like -

> Next stop **Montreal**
> Arriving in **2 hours 25 minutes**

A clock in an on-board computer could be used to change the time or the system could be driven by a central computer. Other preprogrammed messages could be displayed as appropriate, such as;

> We are stopped to let another train pass.
> We will be moving again in 6 minutes.

Special messages could be entered by a keyboard on the train. An example might be;

> The dining car is now full.
> Please wait to avoid crowding.

This sort of additional information could alternate with the basic message about the next stop. Each message should appear for about three times its required reading time. This permits ample time for reading the message, even if the passenger doesn't look at the display right after the change of message. The time is not so long as to discourage the passenger from waiting to see the next message after the first one is read.

An interactive computer information system such as Telidon might also be put to good use on the train for information and entertainment (Barkow et al, 1983).

Information specific to the amenities, facilities and services on the train could also be presented on a VDU or other electronic display. But directional information is more effective if it is spatially associated with the referent. Thus, the sign that directs passengers to the washroom should be near the washroom, and the sign directing passengers to the snack bar should point the passengers in the right direction.

Over the last several years there has been increasing use of pictograms. Although some people speak glowingly of "internationally recognized graphic symbols," these symbols are not standardized. Mackett-Stout and Dewar (1981) report that there are over 50 versions of the pictograph for "men's washroom." Recognition of these symbols is less than adequate.

In studies reported almost ten years apart (Zwaga, Boersema and Rookmaaker, 1973; Boersema and Zwaga, 1981) little progress is evident in the use of pictograms in railways. In the later study, only half of the 29 symbols used were correctly interpreted by a criterion of 67% of the respondents. Such a lax criterion means that most of the pictograms are not recognized by at least one out of three adult passengers.

In both studies, older and less experienced travellers had more difficulty with the pictograms than younger people or those with more travelling experience. Specific information on the types of errors and confusions is cited as a guide to the redesign of the graphic symbols.

The discriminability of different graphic symbols was the subject of research by Geiselman, Landee and Christen (1982). This work is based on requirements to integrate new symbols in an existing symbol domain. Their measures of discriminability were useful in predicting variability in symbol search times in a laboratory task. But the special requirements of the military symbol system employed in this study limit its relevance to public use.

The authors make some very valid general comments about the introduction of new symbols into a system of graphic information. The process of developing a set of symbols requires analysis of:

- the relation between the symbol and the concept being portrayed, and
- the discriminability of the different symbols.

The process is iterative; adding new symbols may require testing and modification of some of the old symbols to reduce confusion.

There are also recent research reports which bear directly upon the type of signs used in passenger trains. Mackett-Stout and Dewar (1981) evaluated various versions of eight different public information signs. Although only two or three of these might appear in a train, the methodology is most useful.

These authors compare the different versions for glance legibility, legibility distance, comprehension and preference. They produce a composite "efficiency index." Glance legibility is not so important on the train and it was not correlated with the other measures. It is more appropriate for analysis of highway signs since their visual exposure to a driver may be brief.

The authors also suggest that some research is needed to determine the relative importance of the factors under different conditions. In many cases, comprehension may be more important than legibility distance or preference between symbols. This is the case with washroom signs.

Simple verbal signs are still quite effective, despite the popularity of graphic symbols. The two types of information should be combined to produce signs that are most likely to be understood.

> The best solution to sign problems is not to need any. When Behavioural Team staff were designing the human interface for the CN Tower telescopes, they were faced with the task of explaining a zoom joy stick in two or three languages. The behavioural solution was to devise a control strategy which was sufficiently clearcut and self-explanatory that no sign was needed. The same logic is used in our station design projects.

A study by Riley, Cochran and Ballard (1982) deals specifically with preferred shapes for warning labels. Their results indicate that visually unstable shapes such as a diamond or a triangle on its point are preferred as warning symbols. For warning purposes multiple, redundant cues are even more important. Situations that are potentially dangerous to passengers must be marked with warnings that all of the passengers will understand.

Various candidate symbols for use on the train should be tested with a representative sample of patrons to determine legibility distance, comprehension and preferences. Graphic signs indicating washrooms, exits, services such as restaurants or bars, first aid equipment, and common amenities, such as reading lights and recliner mechanisms, should be included.

The small operational signs on the train should also be subjected to passenger testing. Often equipment designers put graphic instructions on equipment that they understand intimately. Unless the symbolic instructions are tested on naive subjects, their limitations will not become obvious until they are in public use. Too often even the verbal messages are only meaningful to the design engineer. If passengers are required to adjust seats, and to operate lights, doors, window blinds, etc., simple directional signs can save wear and tear as well as passenger frustration.

CONCLUSIONS

Usage of signs on the train can vary from a small arrow to indicate the direction of force necessary to turn a handle, to complex computer generated displays of train progress information. Pictograms are presently popular but are not always understood. Signs should employ a mix of graphic and verbal cues that have been proven to be effective for passengers who will need or want to use them.

More complex information systems, such as computer generated graphics and videotex, may have some place in future passenger trains, especially since these systems can provide entertainment as well as a variety of information.

1.8 Other Visual Stimuli

OVERVIEW

Visual stimuli inside the train are rather limited. You can look at the ceiling, the walls, the seats, or the other passengers. The view out the window can range from genuinely ugly to breathtakingly beautiful. Passengers are particularly likely to have negative responses to many of the run-down and industrialized areas which trains pass through, near major urban stations.

Efforts should be made to improve the visual stimuli on the train, and to help passengers enjoy the visual stimuli outside the window. Simple steps, such as insuring clean windows, would help significantly.

REVIEW OF THE RESEARCH

Very little research has been done on visual stimuli seen by passengers on long distance trains. There are many comments in travel articles about the beautiful scenery along particular sections of a journey, but not much scientific study. Wichansky (1979) notes, however, that looking out the window is one of the major activities of long distance train passengers.

Several trainsets have included observation cars to allow passengers to enjoy the scenery more (Dorin, 1976). This sort of "best case" contrasts with a more typical state of affairs where passengers can't see the scenery because the windows are too dirty. Dirty windows was cited as a major complaint of Transcontinental passengers in an informal discussion with VIA passenger relations (personal communication, 1983).

Amtrak passengers have had the same complaint (Behavioural Team, 1979). This is one case where a simple human factors problem can have a simple remedy. If station maintenance crews are not able to keep the windows clean, perhaps some specialized equipment for washing the windows should be investigated.

The line of sight is also important to passengers. In airplanes the windows are below the horizon sight line since most passengers want to look down at the ground. In the metro in Lyon, France (Chaine et al, 1982) sight lines were designed so that standing passengers could see the station signs.

The windows in train passenger coaches are generally large and at the right height for seated passengers. However, there is sometimes a problem with the pillars between the windows interfering with the view from some seats. Since the spacing between seats varies depending on the railway and the class of coach, this problem is not easily solved. It is listed as a criticism of the LRC in its review by the FRA (Bachman et al, 1979) that standard Amtrak seating puts many of the "window" seats beside a supporting pillar. It is obvious in the LRC promotional booklet (Alcan Dofasco MLW, no date) that in both coach and day-niter cars the windows don't always line up with the rows of seats.

The coaches should be designed taking the proposed seat pitches into account. A modular approach to interior finishing within a certain type of car (e.g. coach, lounge/snack bar) would allow window spacing to be aligned for maximum viewing of the passing scenery. Other aspects of the windows are described in the section on lighting (1.6) .

Sometimes the passengers would rather not see the passing scenery. In Behavioural Team's study (1979) of Amtrak's passengers and potential passengers many mentioned unpleasant scenery such as junkyards, dirty industrial operations, and run-down neighborhoods near downtown train stations. Several Canadians have had similar impressions here. Passengers dismayed by such scenes should at least be able to pull down their blinds at these times. If the passengers have enjoyed looking at the scenery for several hours or days, their final views before arriving in the station should not be unpleasant.

Visual attributes of the train interior should also be pleasing and relaxing but not too somber. Railroad companies have traditionally made efforts toward "fashionable" interiors. In public acceptance tests in 1972, Behavioural Team found the public highly receptive to seat upholstery with vivid patterns - in urban transit vehicles!

Books on the history of passenger rail (e.g. Allen, 1979; Dorin, 1976) describe the use of colours, plaids, designs and motifs to present a pleasing visual environment for the passengers. The promotional description of the LRC (Alcan Dofasco MLW, no date) contains colours and patterns for seats, walls, trim and floors for different car configurations. These are obviously not randomly assigned, but the basis for colour and pattern selection are not specified.

The other passengers, and an occasional crew member, comprise the other important visual stimuli. Social inhibitions stop most people from staring at other people. But we all notice some aspects of our fellow travellers. Personal preferences and specific states or goals affect people's looking at other people, and their response to being observed. These issues are part of the social/behavioural environment described in a later section of the report. In terms of sight lines, seat orientation, size and shape of headrests, partitions inside the coach, and overall layout affect how much each passenger can see or be seen.

CONCLUSIONS

The main considerations for achieving a satisfactory visual environment are:

First and foremost - Clean windows with a good view to the outside,
Second - A visually pleasing interior environment, and
Third - A choice of visually private and visually public places.

Since sightseeing is one of the favourite activities of long distance train passengers, it should receive a higher priority in the list of amenities maintained by the railway.

1.9 Space

Passengers can use a variety of spaces on the train. They have access to an accommodation space (seat, roomette, etc.) and to shared or public spaces (aisles, bar cars, washrooms, etc.). On public transit and busy commuter rail lines, some passengers may sometimes have to stand in a space of two square feet or less (Fruin, 1976). This level of crowding also occurs on third-world long-distance trains, especially in public spaces at peak times. North American practice aims at providing at least a seat for all passengers on long trips. For more money, the passenger can have a larger seat, an overnight berth, or a roomette.

The spatial features of the passenger environment are critical for two reasons. First, the amount of space provided and the specific layout of that space are very important to passenger comfort. Generally, a fairly large space is preferred. Second, the railway has a limited amount of very expensive space to offer to passengers. This basic conflict means that the space has to be designed to achieve the optimal balance between making passengers comfortable and generating income.

There are ergonomic guidelines for space requirements for some activities (Diffrient et al, 1979; Panero and Zelnik, 1979), but most of this work has focussed on design of work spaces. Some general information exists on recommended spatial layout for non-work areas, as well as more specialized information about such things as aisle width in public transportation vehicles. In addition, there are specific guidelines for wheelchair accessiblility to doorways, washrooms, etc. Much of this basic ergonomic information, such as wheelchair clearances or typical lifting capabilities of short females, can be applied directly.

The construction and finishing of these spaces can be as important as the layout. The looks, feel and smell of the environment must be pleasing. In this area, the technology for producing new fabrics and finishes is far ahead of our understanding of human psychological and physical responses to the new materials. Much of the research on responses to materials is done by the manufacturer, with the inherent limits on its review and disclosure.

1.9.1 Public Spaces

OVERVIEW

Long distance trains have several sorts of public spaces. In modern trains they run the gamut from observation decks to bar cars with dance floors (Dorin, 1976; Allen, 1979). Most cars have public washrooms, unless they contain only roomettes with private washrooms. Almost all cars have aisles or walkways, and some vestibule area at one or both ends of the car. On many long-distance trains there are special cars or special areas for dining, drinking, or watching the scenery. Most have at least a snack bar where fast foods and beverages can be purchased. Some trains have public telephones.

Many of the general ergonomic and psychological design considerations for public spaces apply to long-distance trains. In addition, there are special considerations arising from the severe space restrictions, characteristics of the travelling population, the length of the trip, and economics of providing services.

REVIEW OF THE RESEARCH

The spatial layout of public transportation vehicles is constrained by the size of the vehicle. As in aircraft (Molony, 1979) and buses (Burnicle and Heath, 1979), the most important design dimension for train interiors is the cross section. Clearance specifications for the intended routes and design factors (such as double or single level cars) determine the overall cross section. Tilting mechanisms, such as in the LRC, also come in to play in determining the maximum overall dimensions (Bachman et al, 1979).

Within the overall cross section, there is a passenger space. In buses, trains or planes, there may be two levels of passenger space in some parts of the vehicle. The space restrictions require careful consideration of all the components of the passenger compartment.

The aisle width, for example, can't be based soley on the width of the average passenger. Factors such as the "overhang" of seated passengers beyond the edge of the seat, the sway of someone walking down the aisle, and the space needed to carry baggage, all increase needed aisle space. Plans for wheelchair accessibility (VIA, 1980) may finally make the aisles, doorways and passageways in trains wide enough for a large person carrying luggage.

Another problem in aisles occurs when passengers have to pass each other. It would not be economically feasible to make all of the aisles big enough for a wheelchair and a large person with luggage to pass each other comfortably. Plans for serving refreshments or meals from a trolley also affect the requirements for aisle width. As many airline travellers can testify, it's no fun waiting for the trolley to serve dinner to the whole planeload of people before you can get past it to the washroom.

The overhead clearance of aisles, doorways and passageways can be based on published data on the distribution of heights in the population (Diffrient et al, 1979). This dimension is obviously going to be more restricted in double-decker designs. Bi-level designs also require careful consideration of stairs and hand rails for going between levels.

Places where a tall person could bump his head are common in personal pleasure boats, campers and travel trailers. Inside some sailing vessels even short people can run into the ceiling (BT observations, 1983). But inconvenience, discomfort, and even minor hazards are acceptable to the owners of private vacation vehicles. The entire layout of most of these private vehicles is only marginally relevant to the layout of roomettes. Dimensions for public spaces must be based on the behaviour of typical passengers in public places.

Much of the work in transportation design has concerned public transit (e.g. Hellewell, 1983; Brezina et al, 1973; Fruin, 1976; Ontario MTC, 1974), where less space and more discomfort are considered tolerable. The use of public space on most transit vehicles is limited to getting to or from your seat, or standing if the seats are full. Some transit systems (e.g. BART) were designed to seat most of the passengers. Most are designed to have some passengers standing during peak traffic periods (Fruin, 1976).

Passengers on a long train journey are not expected to stand for extended periods of time. But it can relieve physical discomfort and boredom to be able to get up and walk around. Public spaces suitable for brief periods of standing on long-haul trains include snack bars, vestibules, observation areas, and lounges. Some passengers seem satisfied just to stand in the aisle briefly to stretch. But for longer periods of standing in lounges or observation areas, more space is required. For maximum density situations, such as snack bar queues, areas of two to three square feet per person will be tolerated for short periods. Fruin (1976) described studies of passenger densities in elevators and commuter rail cars. Hungry passengers in line at the snack bar represent a similarly captive audience. More floor space is required for other activities such as eating at a counter or watching the scenery in an observaton area.

Besides sufficient floor space for the number of passengers who might be using these areas at peak times, there are general and specific design needs. Public spaces should have safety features such as hand rails and ash trays. Since the train is subject to accelerations in various directions, this is even more important. As shown by Wener and Kaminoff (1980), clear indications of procedures, and design for traffic flow can reduce confusion and perceived crowding in areas such as snack bars.

Design within lounges and snack bars depends on the amount of space available, the service to be offered, the projected number of patrons at different times, and maintenance requirements. These areas should provide a variety of seating arrangements. This permits people seeking, for example, more or less social interaction to choose a location that suits their goals (Mehrabian, 1976). In addition, different size travel groups require different areas in bars, snack areas and lounges. This is reflected in the designs of modern trains such as the LRC (Alcan Dofasco MLW, no date).

Washrooms are a special instance of public space, since they are usually used by only one person at a time. However, provisions should be made for situations where someone requires assistance from a companion or attendant in the washroom. In lounges and snack bars, multi-unit washrooms may be required. Ergonomics of washrooms are discussed later.

Other human factors issues are described in sections dealing with behaviour in public spaces on the train, later in the report.

CONCLUSIONS

Many of the human factors issues involved in public spaces on long distance trains are the same as for other public spaces. People require different amounts of space for different activities. Considerations of access to people with crutches, wheelchairs, baby strollers, and/or luggage call for fairly wide aisles and doorways. This also makes it easier for a passenger to pass a snack trolley or another passenger in the aisle. Aisle width must be determined in conjunction with seating, berth, roomette, or service area dimensions. The overall cross section of the car is the limiting factor, since the length can be varied more easily.

Specialized public places, such as snack bars, observation areas and lounges, require a spatial layout that passengers will find comfortable for the time and purpose of their excursion to that space. Provision should be made for safe standing where passengers are intended (or are likely) to stand. Seating should provide opportunity for a variety of social groups, from a person who wishes to remain alone in the public place to a large family or business group.

1.9.2 Accommodation Spaces

The accommodation spaces offered on passenger trains vary from country to country and from coach to coach. In North America, the tradition has been for open passenger coaches with an aisle down the centre between rows of seats. European trains, until recently, were more likely to have a series of compartments with a corridor down the side of the car. Sleeping berths and/or roomettes are usually found on overnight and long-distance runs in most countries. Another option is a coach containing large, reclining seats suitable for sleeping.

In some less technologically developed countries comfortable accommodations are only avaliable for a few privileged people. "Second-class" passengers may have to sit on wooden benches or the floor, or stand during long journeys. But, these passengers usually don't have the option of taking a car or airplane to their destination. North Americans tend to demand a more comfortable journey, especially if it is a long one.

Much of the passenger's satisfaction with the journey is determined by the design and construction of accommodation spaces. However, there has not been much systematic study of passengers' responses to specific details of the accommodation spaces in long distance trains. Other studies of reactions to accommodation spaces are of limited use. In some of this work, special groups, such as university students or sailors, occupy an environment continuously or intermittently for weeks or months. The long time-frame, special motivations and limited variability of the subjects make the data and findings irrelevant to the design of long-haul passenger trains. Some cruise lines and hotel chains have apparently conducted studies of short-term accommodation requirements, but these studies are generally considered as proprietary market research, and are not reported in the literature.

The studies that are more relevant are usually based on too short a time span for the 6 hour to 6 day time-frame of Canadian long distance passenger trains. However, they provide much useful information. The accommodation spaces are reviewed in three main groups: seating, sleeping berths, and roomettes.

1.9.2.1 Seating

OVERVIEW

The typical position of passengers on most long distance journeys is sitting. In many cases, the only accommodation provided for the passenger is a seat and access to luggage storage and public spaces. Characteristics of the seat are major determinants of passenger comfort and satisfaction.

It is no surprise that seating has been the subject of much study. Most of this research deals with chairs in an office environment, where people spend long periods of time sitting. The ergonomic requirements for train passenger seating are condiserably different from that of the office. A number of recent Canadian studies represent a concerted, and successful, effort to develop better seating for a variety of rail passengers.

REVIEW OF THE RESEARCH

In a study of ride quality on commercial airline flights, Richards and co-workers (1975) measured motion parameters and passenger responses. Passengers rated seat comfort ahead of noise, temperature, and motion factors in determining comfort. Of course, the motions and noises on the train are less discomforting than on planes or helicopters. So the seat comfort on the train is even more important. In the study of airline seats most passengers were satisfied with seat firmness but not with leg room or seat width. Seats were not adequately adjustable on most of the planes tested, but the slope was generally rated as comfortable.

In rail journeys lasting from several hours to several days, seat comfort and adjustability are even more important than on short airline flights. And modern seats on long-distance passenger trains are more comfortable than on planes. In the U.S., Amtrak has recently taken out full page ads in popular magazines showing the seat and its comfort features to prospective new passengers.

In addition to the comfort of the seat itself, there are several other issues that influence passenger satisfaction. The most important of these, the amount of space provided, is also better on modern inter-city trains. For example the LRC "high density coach" was designed for a seat pitch of 100 cm and the "day-niter coach" around 145 cm (Alcan Dofasco MLW, no date). Molony (1979) reports a seat pitch minimum of 76cm for the L-1011 TriStar, but seats as close as 65cm are found in smaller planes and commuter rail cars (Hellewell, 1983).

More comfortable seating is available at a higher price on most long distance rail lines. This first class or day-niter arrangement is characterized by a greater seat pitch (more room between rows of seats.) The seats are usually wider, recline farther, and provide more support for the lower leg when reclined. The seats are commonly in a 2+1 layout instead of the 2+2 found in regular coach. This results in wider gangways (aisles.)

Additional amenities may include better individual lighting, meal service, blankets and pillows at night, and larger washrooms. Other variations of first class accommmodations include such things as face-to-face meeting tables, conference rooms with audio visual equipment, separate first class dining rooms and lounge areas, etc. The spatial layout of these accommodation spaces often includes more options for seating. Rows of seats facing each other with a table in between provide a social and activity space for a family or small group. Individual seats wih a more private social environment are also present.

The amount and variety of space in first class are obviously preferred by some travellers. For other travellers they may be seen as necessary. Many obese people require the wider seats provided in first class. Others may require solitary, conference or other seating. The ability to offer a variety of seating arrangements is worth the additional charge to many travellers.

Of course, the more basic determinant of comfort is the seat itself. In Canada's "Rail Seat Development Program" several tasks were undertaken to improve rail passenger seating. The overall program is summarized in a report prepared by Gillies (1980). The 16 separate studies that contributed to the summary report describe the various stages of development of the seat and analysis of prototypes from strength and vibration testing to passenger evaluation.

In a companion program a tie-down system was developed for improved rail seating of passengers in wheelchairs (Ball Berezowsky Associates, 1978; Heron, 1980; Heron et al, 1983).

Both programs achieved their stated goals. The wheelchair tie-down seems flexible and practical. It has not had as much in-service testing as the passenger seat, and those who use the tie-downs in the future will surely be able to suggest other modifications to their seating environment to improve comfort, particularly for very long voyages. One consistent comment (Heron, 1980) has been that they do not want to be isolated from the rest of the passengers. VIA's implementation of the wheelchair tie-down (VIA, 1980), and other improvements for passengers with special needs, will greatly improve accessibility for the handicapped.

The ultimate version of the passenger seat (Mark IIb prototype) compares favorably with many other popular production seats. Some areas still require improvement. The food tray assembly is well liked by passengers but doesn't fare well in strength or durability tests. As in many other seating studies, the requirements of exceptionally large or small people were not addressed in the in-service tests. However, the work reported by Noy and Crabtree (1978) deals solely with the responses of subjects who were large, small, handicapped or elderly - those "most likely to experience difficulties."

Even more important for the present discussion is the fact that passengers who evaluated the seat were on a relatively short (five hours) journey. Laboratory sitting tests, conducted by DCIEM (Noy and Crabtree, 1978), were limited to four hours. Longer trips lead to more passenger discomfort. More space and adjustability are required to permit a greater variety of body positions. On extended trips (overnight or more) it is also necessary to adjust seats to a comfortable position for sleeping. Such long term effects of seats on passenger comfort haven't received much study.

Recent work on methodological issues in evaluating chairs (Drury and Coury, 1982) suggests that testing involve the tasks for which the seating is designed. Besides giving much valuable data on seating dimensions and properties, this research outlines the kind of questionnaires required to evaluate subjects' responses. Drury and Coury used general comfort ratings, body-part discomfort scales, and a checklist of chair features for different users and at different times over the test period. This evaluation was conducted for office chairs but the same approach would be useful for evaluating long-term responses to rail passenger seating.

CONCLUSIONS

Seating is a prime factor in passenger comfort. Long-haul trains must continue to offer more comfortable seating than planes or buses to attract travellers. The quality, adjustabilty, variety, and spacing provided in train seats increase with the price level of the ticket and, often, with the distance of the journey.

Canadian studies in rail passenger seat development have addressed many of the basic design issues. The resulting seat compares favourably with others on the market, but still requires some minor improvements. Related work has resulted in the implementation of wheelchair tie-down devices in passenger coaches.

Further studies should be directed at known comfort factors over the very long exposure times found in cross-country Canadian rail travel. Methods exist for determining the specific features of the seat that need improving, and the specific parts of the passenger that are uncomfortable.

1.9.2.2 Sleeping Compartments

OVERVIEW

Passengers' requirements for sleeping accommodations vary. The provision of compartments specifically for sleeping has a long history in railroading. Sleeping berths are even provided on some long overnight airline flights. However, recent psychological and ergonomic literature contains very little information about the requirements of these specialized sleeping places.

Recent railroading practice seems to have moved away from the "dormitory" type of arrangements to berths within roomettes or rooms. There may still be some scope for operation of cars, or sections of cars, with smaller berths strictly for sleeping. But modern day-niter seats offer almost as much sleeping comfort.

REVIEW OF THE RESEARCH

There are no recent articles in the ergonomic, psychological or railroad literature on the type of sleeping accommodation that contains only berths. This sort of accommodation consists of upper and lower berths separated from the corridor by heavy curtains. There are usually single berths on both sides of the gangway. Sink and toilet facilities are shared by the passengers.

The same factors that made this type of coach popular in old comedy movies (e.g. Some Like It Hot) may be related to its lack of popularity with the public. The upper berths are difficult to enter and the person in the lower berth sometimes gets stepped on in the process. Changing clothes in such a limited space also causes problems. The curtains provide only limited privacy since they can't be locked and they allow a great deal of sound transmission.

It is typical of facilities such as berths that there are many "tricks" known to experienced riders which improve their comfort. Sleeping on the toilet couch instead of in the berth is one such piece of wisdom! Another pointer is to put your clothes near the outside wall of the train, not on the corridor side of the bed. Waking up to find that your clothes have fallen out into the corridor could generate considerable discomfort, especially if the other passengers are looking out of their berths to see how you retrieve them.

Alas, these bits of wisdom get lost as new passengers begin their train riding careers. This is more and more true today as more of the passengers are sampling train travel, rather than using it regularly.

Particularly in the case of two or more people travelling together, a bedroom is a more practical sort of sleeping accommodation. More passengers can be put into a coach in sleeping compartments, of course, but only when that coach is fully booked. Some passengers may prefer a flat bed with a curtain for some privacy, but many are satisfied to sleep one, or even several, nights in a comfortable reclining chair. Another problem with upper and lower berths is that they are not really habitable except while lying down. Roomettes and bedrooms can also serve as a sitting room when the beds are folded away, but the passenger who sleeps in a compartment needs additional accommodation space when not sleeping. This makes the sections containing small sleeping compartments useless except during late overnight trip segments.

A mix of sleeping accommodations within each car is often adopted in a "something for everyone" approach. VIA's present fleet of mixed accommodation sleeping coaches (Caird, personal communication) contains several different combinations of roomettes, double bedrooms, and sleeping berths.

Minimal sleeping accommodations such as upper and lower berths wouldn't be the first choice of very many people. However, such minimal spaces do cost less than a room or roomette. The development of "sleeping capsules" in some Japanese hotels is based on similar market considerations - space is limited and expensive, and the market contains people who will accept minimal sleeping quarters if the next better level of available accommodation is out of their price range. Unfortunately, the human factors issues considered in the design of these "sleeping capsules" were not described in any of the articles uncovered in our extensive computer and manual search of the psychological and ergonomic literature. Later research on international practice in accommodation will pursue other methods to analyze the human factors and market acceptance of these minimal accommodations.

Although market research can provide some guidance as to the mix of accommodations that might be preferred by the travelling public at any one time, these preferences are subject to change over the anticipated life of the car. Designing the cars so that modules of one sort of accommodation can be replaced by or converted to another kind of accommodation, provides added flexibility.

CONCLUSIONS

Small sleeping compartments are still found on trains in some countries. Often they comprise only a small proportion of the sleeping accommodations within a particular car. There are several problems and limitations with this sort of compartment. Ergonomic problems such as head clearance, space for changing clothes, and access to upper berths combine with psychological considerations such as limited privacy to make these compartments less than ideal.

Analysis of market trends in sleeping accommodations will be required to determine the place, if any, of this sort of sleeping accommodation in new sleeping coaches.

1.9.2.3 Rooms and Roomettes

OVERVIEW

Rooms of various sorts are offered on many long distance trains. The design of these rooms permits many activities to take place there, including sleeping, changing clothes, sitting, socializing, working, and using the washroom. There is also typically some space for hanging clothes and storing luggage. With some food, or food service by rail staff, these units can be self contained and the passengers could stay in their room for days if they wanted.

Because of the cost of these cars, optimum use must be made of the space. Needs for flexibility (e.g. converting two double rooms into a family suite) also influence the design. Similar considerations have influenced the design of yacht interiors, but these are based on an entirely different design envelope. Access to the outside of the yacht also decreases the importance of things such as head clearance.

REVIEW OF THE RESEARCH

A number of articles have provided much of the design detail and rationale for the new British Mk-3 sleeping car. Perren (1979) described the marketing and other considerations that led to the development of the Mk-3 to replace the old Mk-1 sleepers on certain routes. In addition, some of the special features of the new car are described. Later articles provide more useful information on these construction and human factors details.

Perren (1982) rehashes the same issues of market and timing advantages and again lists a few of the special features. The relevant specifics are better described in two articles by BR engineers (Hill, 1981; Hill and Garratt, 1982.) The later article actually contains all of the relevant information about the car itself, as well as data on the development effort required.

The passenger seems to have been well considered in the design of these sleepers. Special attention has been paid to reducing noise in the passenger compartments. The result is a ride that is only half as loud as in the regular Mk-3 coach. Another major issue in the Mk-3 design is fire safety. The latest methods and materials have been employed to insure maximum safety. Hill and Garratt (1982) list both the noise reduction measures and the fire safety measures in detail. One item mentioned is specified more precisely in the earlier article (Hill, 1981.) A small hammer in each compartment is the "emergency equipment ... to facilitate escape through the windows under emergency conditions" (Hill and Garratt, 1982.)

Limited catering facilities are also provided in the attendant's quarters. This is not a full galley, but permits preparation of beverages and pre-packed foods for a "refreshment" standard of service.

The bed arrangement provides for a single lower berth for first class, or an upper and lower bed in the room for second class. The rooms are the same but the upper bed is folded into the dividing partition for first class. Pairs of rooms have communicating doors so that they can be used jointly by a family or larger travel group. There is hot and cold running water in a wash basin and outlets (both Continental and British standard) for electric shavers in each room. Each room is not provided with a toilet, however. Two controlled emission toilets are provided in each car to serve up to 26 passengers. Holding tanks permit these toilets to be used at any time, including while stopped at the station. These tanks require emptying at special depots.

Amtrak uses double-decker cars for some of their bedroom accommodations. These cars may also contain a galley on the lower level. These bi-level cars seem well suited to offering a mix of various service and accommodation areas (no author, 1982.) Another approach was adopted in the Talgo train (no author, 1974.) Rooms have either two or four berths each arranged on an angle. This permits more full-length beds to be placed in the limited space available. The resulting recesses in the outside corridor permit passengers to pass each other more easily.

The design of the T2 sleeping car had an intricate interlocking of upper and lower rooms, but limited headroom and construction complications led to a change for the T2S (no author, 1974.) The newer version has compartments all on one level, seats and a wash basin in each, and two toilets at one end of the car.

The general trends in these new cars include the following;

- shared toilets for each car with a wash basin in each room,
- limited catering facilities,
- special efforts to reduce noise and retard fire, and
- various accommodations provided by different room designs and folding beds.

CONCLUSIONS

The design and layout of rooms and roomettes varies depending on the particular market served and the design constraints of the trainsets involved. It is common to offer different room accommodations within a single car. In all cases an attempt is made to use the space to its fullest. This requires some changes within the room over the course of a journey, such as folding up the bed. The specific human factors involved in these activities have not been described.

The various designs demonstrated in the literature provide helpful information for designing new sleeping cars.

1.9.2.4 Materials and Fabrics in Accommodation Spaces

OVERVIEW

The previous sections have made some mention of the construction of accommodation spaces. Comfort in these spaces is strongly affected by the actual physical contacts between the passenger and the environment. In some areas the passenger will contact hard surfaces such as metal, glass, wood or plastic. These materials provide durability, stain resistance, and other features that make them suitable for heavily used or food oriented locations. Glass or plastic can also provide transparent barriers.

But most of the contact between the passenger and the train environment is contact with some fabric or textile covering. Many recent advances in textile technology are aimed at enhancing the comfort and appeal of fabrics. There is a tremendous variety in the fabrics now on the market. This variety, and the high level of textile technology complicate the selection of materials for passenger contact.

REVIEW OF THE RESEARCH

Passengers contact several kinds of textiles on the train. Carpeting is widely used as a floor covering. It is also used as a wall covering and as covering for luggage racks. Carpeting has several desirable features for use in passenger train interiors. The comfort and aesthetic features of carpet materials are discussed first.

The passengers' next contact with fabrics, after the carpet, is the covering of the seat. Upholstery has a long tradition in the rail business since it was one of the first amenities added for passenger comfort. However, there is not much recent research on the ergonomic or psychological features of upholstery fabrics.

Finally, there are several other fabrics that the passengers touch in some ways. In the basic seat, the rail company may provide a blanket or cover for sleeping. In berths or rooms, sheets and blankets are provided. Towels, window shades, curtains and other fabric wall coverings may also be present.

There are many passengers who would like even more fabrics on the train. But a tablecloth can't be maintained as easily as a plastic table top, and paper napkins are nearly universal.

As in other areas of textile technology, much of the research and development is conducted by the manufacturers. Consequently, the research reports can be expected to contain biases. However, this industry information still provides valuable information about available materials. An example of this sort of industry report is the Dupont booklet, "A Guide to Contract Carpeting." It describes everything from the microscopic details of the fibre design to suggested maintainence and cleaning procedures. The issues relating to passenger comfort include the following:

* carpets provide a safe walking surface that is easier to keep clean than a hard flooring,

* carpeting helps in the sound and thermal insulation of the passenger compartment,

* colour, lustre, pattern and other features of the carpet can improve the appearance of the accommodation spaces,

* on the negative side, carpets can retain stains and odours, and can generate static electricity.

The exact carpet specifications depend on the location (Beath et al, 1972). For example, a more durable, resin impregnated carpet is required for entranceways where mud, snow and slush are tracked into the train. But the carpets in roomettes and under seats should be more comfortable. In general, railway accommodation spaces require a floor covering that is comfortable and attractive, long wearing, and easy to maintain. In addition it must be flame resistant and must not produce toxic fumes in a fire. There are several methods which are used to test properties of carpets such as abrasion resistance, colour fastness, flammabilty, and static electricity. Similar tests are applied to fabrics for other uses such as sheets and curtains.

All of these factors can be specified for carpets to meet certain performance criteria. The yarn has properties determined by the material and its fabrication. Specific combinations of materials will be required to achieve the right mix of features, such as flame resistance and soil masking. Bulk continuous filament (BCF) yarns are most suited for heavy traffic areas, but cut filaments produce a thicker and softer carpet. The methods of bulking and crimping, as well as dyeing and other chemical treatments, affect features such as lustre and shedding. Nylon or nylon blends seem to have several advantages over other fibres in terms of most properties. However, nylon is worse in terms of static electricity. An acceptable level of static generation is about 3 KV at 20% relative humidity (RH) and 20 degrees C. There are treatments to both the fibres themselves (carbon core, metallic fibres) and to the backing which can reduce static.

Kolker (1980) discusses the recent developments in use of colour in carpets. We have come a long way in the past 20 years, progressing from a choice of about eight colours to thousands of possible colours and methods of colour mixing. This is another feature that can be specified before manufacture for large industrial orders. The psychological aspects of colour are alluded to in some of the carpet industry reports, but the statements seem to have come from designers, not from social scientists. In a paper by Wineman (1979) some of the claims about the effects of colour on human behaviour are reviewed. Apparently, even the social scientists do not have a very clear picture based on hard data. The only solid suggestions would be to avoid extremely "cold" or extremely bright carpet colours.

Carpet colouring can also be used to indicate pathways, designated areas, changes in floor slope and other information functions. One use that relates to territory of the individual passenger is marking the division of floor space between seated passengers with a change in carpet colour. The increased clarity of the allocated space would reduce possible anxieties and conflicts.

The seat upholstery is the fabric contacted most by the passenger. The design of the seat is clearly important to comfort, but specific features of the fabric also contribute significantly. The fabric must be comfortable, but this aspect is somewhat hard to define. A term used in the textile industry for some aspects of comfort is "hand." This refers to the feel of the fabric when it is handled. A variety of approaches have been taken to quantify these comfort parameters for textiles. These issues also apply to other fabrics encountered on the train, especially bedsheets.

Vaughn and Kim (1975) and Paek (1979) have reviewed the research on assessment of "hand" in textiles. The research in this area has involved both subjective assessments of hand and measurement of physical properties affecting comfort. The most useful studies are those that use both approaches to relate the physical properties of fabrics to human sensations of comfort or discomfort. The statistical methods employed to relate the two types of data include rank correlation, multiple factor analysis, component analysis, regression analysis, decision theory and "handmetry." This last approach is an adaptation of traditional psychophysical procedures. Subjects provide data linking "just noticeable differences" in the feel of fabrics to objective measures of 34 physical properties. The value of this last approach is that, once reliable psychometric functions have been generated, comfort attributes can be described for new fabrics on the basis of purely physical measures.

The cluster analysis of different fabric hand properties by Paek (1979) seems less valuable in terms of specifying the important physical properties of the materials. The resulting clusters and distances can tell you which fabrics are seen as most similar, but the relation to comfort is less clear than in the "handmetry" approach described above.

Another approach to measuring fabric comfort is described by Olsen and Broome (1977). Subjective ratings of comfort were related to physical measures of pupillary responses resulting from contact with the fabric. The subjects' pupils dilated most to the fabric judged most comfortable, and constricted in response to textiles that felt the least comfortable. However, the relationship was not statistically significant. The authors claim that this is because the pupillary response to comfort is more sensitive than subjective report. The work by Olsen and Broome may not generalize well to other cases since they were studying only responses of females to shirting material, but the approach deserves further study. In the meantime, results from the studies of fabric hand provide some guidance as to properties related to comfort.

The physical features that seem to be most important in determining "hand" are listed below along with the subjective quality which they determine (Vaughn and Kim, 1975);

* flexural rigidity, bending modulus, hardness, thickness, density, compression modulus	softness
* surface friction, cover factor	smoothness
* crease resistance modulus	liveliness
* water permeability	thermal comfort

Besides conforming to performance and safety requirements (Beath et al, 1972; Guillon et al, 1979), fabrics used in upholstery should be tested for comfort using either subjective measurements or physical factors which have been shown to adequately determine comfort. Ingham and Edwards (1982) and Seidel (1981) both site wool as a constituent fabric which enhances comfort, safety and maintenance. Other factors besides the constituent fibres, such as twist, weave and count, also relate to comfort and maintenance properties.

Several recent articles deal with comfort properties of the other types of fabrics likely to be found in a long-haul passenger coach. Bedding, blankets, curtains and towels have extensive use in both homes and institutions. Their large market has made extensive study of comfort and maintenance necessary.

The thermal properties of bedding and blankets are reviewed by Taylor (1980). The thermal requirements for bedding differ with the room temperature, the user's age, and preferences of the individual. It is better to have multiple layers of blankets which together can provide the maximum necessary insulation, rather than one blanket, duvet, etc. which would sometimes be too hot.

Hassenboehler and Wyatt (1979) describe a simple test for the lint loss and appearance change that can be expected of a blanket with use. An "Accelerotor" abrasion instrument successfully replicates the effects of long-term use in a simple and quick procedure. This type of test would be valuable in choosing blankets that will best survive continued launderings.

Other general information about textile properties, as well as specific information about towels and curtains, are contained in reports by Richards (1981) and Taylor (1980, 1983). Some recent developments which may be relevant to fabric choices for use in rail passenger accommodation are listed below;

- sheets (developed by Fieldcrest) which are made from fibres with a polyester core covered in cotton (These combine the service properties of the synthetic with the hand, or feel, of cotton),
- textile wall coverings containing flame resistant modacrylic fibres,
- flame resistant polyester for curtains,
- and new dyeing and printing techniques that open new possibilities for decorative effects.

There are some attributes of textiles that haven't received much attention. One of these factors sometimes mentioned by train travellers is the "musty smell" of old upholstery, carpets, etc. This property has not been measured well, nor are there specific maintenance treatments suggested. Products are on the market which claim to alleviate these problems in home carpets and upholstery. Perhaps these could also be useful in a railway's maintenance programs.

Another aspect which has received limited attention is allergic reactions to materials and fabrics used in accommodation spaces. In its long-range plans for improving services to passengers with special needs, VIA (1980) proposes to use "non-allergenic materials for interior furnishings." However, recent research on allergic reactions and chemical sensitivities (e.g. Small, 1982) points out that an incredible variety of substances can cause adverse reactions in at least some of the population. The task of analyzing all of the possible combinations of materials, glues, fibres, dyes, sizings, and other chemical treatments for possible allergic or sensitivity reactions would be massive. The main problem with this sort of research is the incredible variability in people's reactions to chemicals or allergins.

CONCLUSIONS

The textile market has seen rapid advancement in recent years. New fibres and combinations of fibres are available. New methods of manufacture, treatment and assembly of textiles make the variety of textile choices almost endless. Testing techniques are now available that relate physical properties of the fabrics to subjective assessments of comfort. Some understanding of the "state of the art" for textiles can help the designer make optimal use of the wealth of information available from fabric manufacturers and suppliers. The main considerations for textiles in the train - comfort, safety and maintainability - can all be specified and measured precisely before the fabric is ordered.

Since most of the passenger's physical contact on the train is with fabric covered surfaces, correct specification of fabric properties can significantly enhance passenger comfort and satisfaction.

More information is required about passengers' reactions to allergins, chemicals, and new or acquired odours present in the materials and fabrics used in accommodation spaces.

2. Behavioural Variables

The previous section of the report deals with human factors in terms of the environmental variables on long distance trains. The next section has the behaviours, rather than the environment, as its primary focus. The behaviours are described in a sequential order.

2.1 Boarding and Leaving the Train

OVERVIEW

There are numerous human factors considerations before the passenger gets to the train but issues of ticketing, stations, etc. are outside the scope of this review. The first passenger behaviour involving the ergonomic design of the train is boarding. Since alighting involves the same steps, doors, and handholds, these two behaviours are considered together.

Psychologically, these first and last behaviours are likely to have special significance to the passengers, despite the fact that they occupy a very small portion of the trip time. Smoothing the passenger's transition into and out of the train can make the whole trip more enjoyable.

REVIEW OF THE RESEARCH

Getting into and out of vehicles is a major transportation problem. People with chronic or acute physical disabilities may have particular problems, as do people carrying luggage. There are few studies of boarding or alighting long haul passenger trains. There have been several studies, however, of boarding and alighting transit vehicles.

Some of these studies deal with the effects of crowding on the dwell time at stations. An example is the work reported by Fritz (1983), which is quite elegant in its mathematical modeling. But the high levels of crowding on the train and platform, the bravity of the stops at each station, and the characteristics of the travelers make these transit studies fairly irrelevant to long distance passenger trains. One feature that is common in subway trains and would be an improvement for other trains is raised platforms (or sunken tracks.) A level entrance to the train is necessary in subways to reduce dwell times. It would facilitate entry into other trains, even though the time taken for boarding and alighting may not be critical to operations.

A study entitled "Passenger problems on moving buses" (Brooks et al, 1980) looked at two relevant issues - step height and handholds. A retractable step with a height of 185mm improved the ease of boarding and alighting for both young and elderly passengers. Trains have traditionally provided a small step placed on the platform to improve the ease of access. A retractable step fixed to the car provides more secure footing. It should not protrude from the side of the car when it is running or in a station with elevated platforms.

Handholds are critically important at all steps or sloped areas. The preferred handhold dimensions for the sixty elderly subjects surveyed in the study of bus boarding and alighting were as follows;

- vertical and sloping portions, with the sloping rail at a 1m height,
- an oval section rail 32mm X 18mm,
- a surface finish which minimizes slipping for axial forces, and
- at least 70mm clearance from the handrail mounting surface.

Small children may require a parallel handrail at a lower height. Luggage also increases the difficulty of boarding or alighting. This issue is discussed in section 2.3, below.

Boarding and alighting assistance of various sorts may be provided by the railroad crew. This is particularly helpful for people with some limiting condition such as injury, pregnancy, old age, or small children (Waterhouse, 1979.) For passengers in wheelchairs, special lifts make boarding and alighting much easier for passenger and crew (VIA, 1980.)

CONCLUSIONS

Boarding and alighting are important because of the human factors problems involved, and because of the psychological importance of these transitions into and out of the train. Few studies have investigated the ergonomic factors. Handholds and proper height steps are very important, as is assistance to passengers requiring it. Level entry (raised platforms) would make boarding and alighting easier and safer for all passengers.

2.2 Locating Your "Territory" on the Train

OVERVIEW

Once the passenger has entered the train, the next task is to find their accommodation space. The space may have been reserved previously, and the passengers may be escorted by one of the train personnel. Alternatively, it may be "first come first choice." In either case, train travellers begin to feel more secure when they have identified their temporary territory.

The factors influencing assignment of space or choice of seats are important for both design and operation. For example, the typical size of travel groups should influence both the variety of seating arrangements in coaches and the option to reserve a group of seats together.

REVIEW OF THE RESEARCH

Popular and scientific literature abounds on the topic of human territory. It is obviously an interesting topic, but there is no clear consensus that describes all instances of "territorial behaviour." Psychologists, ethologists, ecologists, sociologists, social geographers, psychiatrists and many others have all contributed to the study of territory.

Many of the studies deal with permanent territories such as homes and neighborhoods. The features of a territory on a train may be very different but some of the functions are the same. The persons's territory provides some degree of security, privacy, and stimulus regulation, and it satisfies some psychological needs for identity, home-base safety, and status (Malmberg, in Sossin, 1982.) Passengers will prefer one type of territory over another based on their needs and their assessment of the available spaces.

A very detailed study demonstrating the complexity of seat choice is reported by Collett and Marsh (1980.) They observed seat choice, by different sized groups, in an airport lounge. There were three different seat arrangements to choose from, each containing 16 seats. The results and analyses are complicated since the choice of available seats is continually changing. The choices available for one travel party depend on the choices already made by others.

Single travellers preferred a seat on the periphery if there was no one in the adjacent seat. If they had to sit beside someone, they chose on the basis of least density, rather than central versus peripheral seats. The preferences of pairs were based on the ability to sit side by side, also with some tendency to less crowded areas. Groups of three or more tended to choose seats where they could converse easily. These larger groups had more difficulty finding an acceptable number and arrangement of seats, and some members of the group often had to stand to participate in the group interaction.

The seat choices made on the train will be influenced by other factors, of course, such as windows, no-smoking areas, or proximity to the bar car. In addition, some of the passengers on a long train trip can be expected to want more social interaction with strangers than is common in airport waiting lounges. But the study in airport lounges confirms some general conclusions;

* different sized travel groups have different seating preferences,
* choices depend on the spatial layout of the seats and the presence of others,
* groups of three or more prefer a layout where they can see and talk with each other easily,
* singles are more socially constrained in their seat choice than pairs or groups, and
* singles or pairs may occupy spaces designed for larger groups and prevent their optimum use by the larger groups.

Optimizing the use of seating space on the train may require not only making spaces available for larger travel groups, but also reserving them or putting up signs to discourage individuals or pairs from sitting there. The distribution of different sized travel groups is very important in determining the solutions to the issues involved in the choice of seats.

Another aspect of territorial behaviour in trains is marking seats. This may involve draping coats over the seatback or placing luggage on the seat. This marking may seem merely like a convenient handling of belongings when the passenger first gets to the seat. But it is identical to the behaviour that passengers use to mark their space when they go to another part of the car or train for some reason (e.g. when they go to the washroom.)

The factors affecting the choice of a room or roomette, or a first-class seat, rather than a regular coach seat, have not received much study. These choices are generally made before the travellers get on the train. The issues of personal space and sense of privacy clearly play a role. The size and other features of the travel group are also important.

If accommodation spaces are reserved, passengers merely have to locate their space rather than choose it. They generally receive directions from one of the train crew, but clear signs could serve this purpose. The crew member can be very useful, however, in helping with luggage and describing certain features of the accommodations, such as how to fold the bed down at night.

Some passengers may actually ask for a different space or another level of accommodation after they get on the train and assess their space for adequacy.

Much of the other research on choice of spaces involves an issue related to territory - personal space. Ciolek (1982) presents information indicating that the zones of personal co-presence are determined by the distance requirements of the different senses. Touching range is within 1 meter. Anyone within one meter is considered to be very close. Actual touching between strangers, and even friends, is generally avoided. Obstructions such as partitions and high seatbacks can reduce the effects of close proximity.

The next larger rings in the personal space zones, and the relevant senses are;

2 m	touch mediated by tools,
8 m	smell,
30m	hearing, and
90m	sight.

These distances are different on the train because of the masking effects of air conditioning, background noise, and barriers such as doors. An analysis of the behavioural space in trains could better determine the limits of different personal spaces in that environment. For example, passengers in an open coach may be able to hear some passenger sounds from the other end of the coach while persons in a roomette might only be able to hear some of the sounds from the corridor and the adjacent roomette.

Depending on their psychological state, individuals may want more or less personal space (Bowers, 1979.) By providing a variety of accommodation spaces, people's varying preferences can be satisfied (Mehrabian, 1976.) Optimum design of the spaces on the train requires some information about the typical travel groups and their particular spatial requirements.

CONCLUSIONS

If passengers have reserved spaces, directions to and identification of these spaces should be clearly displayed or presented by a crew member. If the spaces are not reserved seats will be chosen based on judged suitability for the travel group. Considerations include visual access to other group members, as well a proximity to windows, tables, exits, etc.

If there are special areas designed for larger groups, individuals or pairs of passengers may prefer to occupy these spaces unless they are actively discouraged.

2.3 Handling Luggage

OVERVIEW

Train passengers generally carry their own luggage on to the train and prefer to keep it near them during the trip. This can cause problems right from the start since boarding can be difficult with a load of baggage. Other difficulties occur when luggage competes with passengers for floor and seat space. Some passengers require assistance with their luggage.

Proper design of luggage handling and stowage facilities can ease boarding and alighting congestion and improve rider satisfaction.

REVIEW OF THE RESEARCH

Waterhouse (1979) indicates that baggage causes space constraints on planes, buses and trains. This is because people want to keep their luggage in view and tend not to put heavy bags into overhead racks. The luggage can end up on a table, in the gangway, on the passenger's lap, or in another seat.

In passenger studies, baggage is also cited as a problem during boarding, especially when no assistance is available.

In one of the only studies dealing specifically with train passengers' luggage, Williams (1977) confirms these observations and makes several other valid points. Luggage stowage between the backs of seat rows facing in opposite directions has some advantages, because heavy items can be near the floor level and close to the passenger without getting in the way. Overhead racks have several problems. Passengers may have fears about bags falling, particularly if someone else put them in the rack. The rack depth will be too small for the largest bags, while smaller bags may disappear from sight and be hard to retreive. The height of the rack is bound to infringe on the space of the tallest individuals while still being out of the reach of the shortest people.

Overhead racks may still solve more problems than they create, but their design obviously involves compromises. Train crew should expect to assist some passengers in stowing their bags. This help is not only required by people with obvious disabilities. For example, coronary patients should avoid lifting luggage into luggage racks because of the particular effort and movement required (Huellemann, 1980.) Passengers may also require some direction from crew in order to keep gangways clear of luggage.

Williams (1977) provides much valuable data on the number and size of luggage items carried by different groups of travellers. Holiday travellers usually have more bags than business or other passengers, with some bringing as many as 8 bags. About 90% of business travellers and over 80% of "other" passengers have more than one bag. The average piece of luggage has the following dimensions;

Dimension	Mean	Standard Deviation
length	51cm	14cm
width	18cm	5cm
height	37cm	9cm
weight	8.4kg	5.1kg

A small sample of observations in a Canadian long distance train could confirm the applicablity of these data and conclusions.

CONCLUSIONS

Long distance train passengers can be expected to have several items of luggage. Getting them onto the train and into a storage area that is nearby and seems safe are the main problems. On extended journeys, occasional needs for access to baggage contents can cause other space problems. Careful consideration of luggage storage areas may alleviate some problems. Other problems, such as the height of overhead racks, must be based on informed compromises.

2.4 Activities in the Accommodation Space

2.4.1 Sitting

Sitting is obviously the most common posture for passengers on the train, unless it is strictly an overnight run. The seats provided in all areas of the train must be comfortable for long periods of sitting. The issues involved in seat comfort have already been described (see section 1.9.2.1.) From the behavioural perspective it is important to remember that people don't always sit "properly." On a long trip, more postures will be employed to relieve discomfort in specific body parts and to reduce boredom.

As mentioned previously, longer term passenger studies are required to determine these special characteristics of long duration sitting.

2.4.2 Reclining

One of the ways to allow more variability and comfort in seating is to permit the seat to recline. Behavioural problems in this regard include:

- reclining mechanisms that are difficult to find, understand, or operate,
- interference of recling one seat with the space, food tray, etc., of another seat, and
- specifics of the reclining mechanism that could trap fingers, purse straps, etc.

Reclining is particularly helpful for sleeping, primarily because it permits relaxation of the neck muscles.

2.4.3 Reading

OVERVIEW

Reading is a primary passenger activity on trains. The studies reported here by Wichansky (1979), Jacobson and Martinez (1974), Richards and Jacobson (1975) and Rudrapatna (1979) also include activities such as talking, writing, eating, drinking and looking out the window as determinants of passenger comfort. However, these studies will be considered under the present section for the sake of uniformity and because reading is one of the main activities in which passengers engage on trains.

REVIEW OF THE RESEARCH

It has been agreed by experts on ride quality that passenger activities play an important role in determining passenger comfort (Wichansky, 1979). The ability to engage in such behaviours as reading, writing, eating, drinking and looking out the window contributes to passengers' feeling of satisfaction and well-being during their trip.

From the questionnaire responses of air travellers, Jacobson and Martinez (1974) identified work or "inflight activity" such as reading to be one of four dimensions of passenger satisfaction and comfort. The authors conclude that ."..the ability to work while in flight is...closely related to comfort...(and)...essential to a person spending many of his working hours 'en route'" (p.52). Activities were ranked according to their relative importance as follows (from most to least): reading, thinking, viewing, eating, talking, writing, daydreaming, sleeping, drinking, smoking, and walking in the aisles. The subjective importance of activity was also reflected in passengers' rating of factors considered to be important in determining aircraft comfort. Approximately 80% of the respondents to an interview considered lighting to be at least somewhat important and approximately 55% considered workspace to be at least somewhat important. These interior design features probably help passengers' ease of performing such activities as reading and writing.

Richards and Jacobson (1975) gave similar questionnaires to ground-based and in-flight airline passengers. When asked to rank the activities according to the relative amount of time spent on them, the ground-based sample responded similarly to business travellers in the Jacobson and Martinez (1974) study except that conversation became more important and daydreaming less important than in the earlier study. Respondents agreed that it was relatively easy to read while in-flight. Concentration, reading, writing and sleeping were ranked for difficulty in that order (from least to most) in the in-flight survey. The authors conclude that "comfort level...determines how difficult it is to perform various activities in flight...."

In a study designed to find out what train travellers and non-travellers think about travel on trains, Behavioural Team (September, 1979) conducted twenty focus groups in four American cities on behalf of Amtrak. The groups were designed to reflect distinct user segments of train travellers and non-users. A quantitative content analysis of the focus group transcripts in the form of frequency counts was performed. Fifteen factors emerged among the top ten for all subgroups of the sample: food/bar, expense, convenience of station locations, image, comfort, train personnel, trip time, on-board space, terminals, information delays, on-time performance, sociability of other passengers, and seeing the countryside.

Wichansky (1979) developed a behavioural taxonomy of passenger activities based on observational methods on several Amtrak trains in the U.S. She obtained subjective opinions from passengers regarding the importance of such activities for their satisfaction on trains and the role of ride quality factors - including vibration, noise, temperature, humidity, and light - in the performance of passenger activities. In addition, Wichansky determined the relation between frequency levels of passenger activities and physical and operational parameters of the ride.

The activities observed were: doing nothing, sleeping, smoking, moving, talking-listening, handcrafts, games, eating, drinking, reading, writing, and other. Through observation it was discovered that the most popular activities were viewing (24.4%), reading (24.2%), sleeping (14.4%), and talking-listening (10.9%), which account for almost 75% of all observations. Among the least popular activities were handcrafts (.7%), games (1.3%), doing nothing (2.6%) and writing (3.3%), which account for less than 10% of all observations. The relative number of passengers who were observed reading and writing increased from morning to evening.

A higher proportion of passengers in sparsely occupied vehicles slept and read, while a higher proportion of passengers in the more crowded vehicles engaged in conversations, ate, and drank. Writing appeared to be difficult when the trains were in motion.

Reading and thinking were considered to be important activities by the greatest number of respondents: 87.6% and 85.9%, respectively. These were followed by sleeping (76.1%), drinking (72.9%), looking around (72.6%), eating (70.4%) and conversation (61.9%). Writing was felt to be important by half the respondents and unimportant by the other half. Games and handcrafts were considered unimportant by the greatest number of respondents (82.7% and 82.5%), followed by smoking (69.5%).

Passenger activity levels are signficantly affected by the rotational motions of the train ride in the 1-20 Hz frequency range. Passengers perceived the ride roughness to interfere with eating, drinking, reading and writing. Noise was also cited as a disruptive factor by 27.1% of the respondents for reading and by 10.7% of the respondents for writing. Poor lighting was perceived to interfere with reading and writing more often than with other activities.

Wichansky recommends improvements in present or future passenger train service as follows:

1. High priority given to providing reading and writing materials, keeping windows clean, and making sure all lights are working.
2. Drinking straws and covers on beverages to facilitate drinking.
3. Provisions for games are unnecessary as these activities are not highly valued by passengers. (However, children weren't interviewed in this study, and video games weren't so popular at the time.)

These recommendations particularly apply to long trips where passenger activities are especially important to passenger satisfaction with the ride. The present levels of noise, temperature, space and other environmental factors are perceived adequate for the type of activities desired by most passengers, but future service should provide a smoother ride. The present levels of ride motion are disruptive to the performance of activities like reading and writing, but don't seem to affect adversely passengers' perceptions of overall comfort.

Rudrapatna (1977) asked passengers on air flights to assess the difficulty of performance and amount of time spent on various activities, using three-point scales. Respondents rated activities from most to least difficult as follows: conversation, dozing, writing, reading, concentrating/thinking, and looking out the window. The order of activities according to amount of time spent was almost the reverse (from most to least): looking out the window and concentrating/thinking (tied for first place), reading, conversation, writing and dozing.

Noise was negatively correlated with difficulty ratings for reading (r= -.61). Significant positive correlations were found between transverse and vertical motions and difficulty ratings for reading (r=.37,.52), writing (r=.69,.62), dozing (r=.77,.8), and looking out the window (r=.34,.34). Discomfort levels were positively correlated with difficulty ratings for reading (r=.54), writing (r=.46), conversation (r=.37), dozing (r=.68) and looking out the window (r=.55).

This study reveals strong relationships between ease of performing activities and physical ride quality, subjective comfort and passenger satisfaction. Rudrapatna (1977) concludes that inferences about passenger satisfaction should be based on subjective ratings of comfort and not on activity difficulty since comfort is judged by passengers as more important than activities.

CONCLUSIONS

Passenger activities play an important part in determining passenger comfort. A study by Jacobson and Martinez (1974) found reading to be the most important activity for passengers. In a study by Richards and Jacobson (1975), concentration, reading, writing and sleeping were ranked for difficulty in that order.

A study by Wichansky (1979) found that the most popular activities were (from most to least) viewing, reading, sleeping and talking-listening, which account for almost 75% of all observations. Games, doing nothing and writing were the least popular activities. Reading and other moderate effort activities were found to be adversely affected by rotational motions of the trains in the 1-20 Hz frequency range. Noise and poor lighting were also perceived as a disruptive factor for reading in one study (Wichansky, 1979) while noise was a facilitative factor in another study (Rudrapatna, 1979).

2.4.4 Talking and Social Interactions

OVERVIEW

Speaking to others is an activity which some people want to engage in on a long train journey. This may be facilitated by the seating arrangement, if it is face-to-face and not facilitated if it is side-to-side or back-to-back. This section reports a theoretical article by Koneya (no date) on talking and privacy and how people negotiate comfortable silences under crowded conditions.

REVIEW OF THE RESEARCH

Koneya (no date) argues that physical proximity and face-to-face orientations are facilitated by certain seating arrangements. He claims that spatial designs create pressure for individuals to speak to each other or interact nonverbally. The face-to-face seating arrangements on many trains is such a situation.

A lone person entering a public space such as a train may be in a state of negative silence which he/she endures with some degree of anxiety or tension. Assuming the individual wants to remain confortably silent, he/she will attempt to avoid talking or eye contact with others. The individual will seek a seat location which will facilitate the conversion of negative silence into positive silence.

A person's choice of seat and/or location in public places such as trains may be an expression of coping behaviour determined by the individual's tendency to interact with others physically nearby. If an individual defines a situation as having high interaction potential but wants to avoid interaction, he/she will try to lower the interaction potential through the use of "environmental props" and "self markers."

An environmental prop can be a seat having a particular interaction potential or a magazine or newspaper held in a reading position and used to isolate oneself from eye contact with others. Self markers include posture, gaze aversion, gestures, and eye contact. Limitations in environmental props and the inability to use self markers on a train will heighten a person's psychological discomfort. In trains there are usually big differences in the degree of privacy one specific location has over another. Conversely there are great differences in these locations in the opportunities to interact.

Functional privacy allows that people can be physically close but still not available to one another. The orientation and spacing of seats and the placement of partitions can enable people to maintain positive silences under crowded conditions. A responsive environment should be designed to permit easy alteration between a state of togetherness and a state of isolation, since privacy is a process in which a person or group sometimes wants to be separated from others and sometimes in contact.

Trains are good locations for design intervention to allow for privacy regulation. Face-to-face seating arrangements should be able to be changed to back-to-back, outward facing seating, or alongside one another.

CONCLUSIONS

A single person entering a train may be in a state of negative silence which he/she endures with tension. The person chooses a seat location which will facilitate conversion of negative silence into positive silence. Interaction potential can be lowered through the use of "environmental props" (a magazine held in a reading position, a seat with a particular interaction potential) and "self markers" (posture, gaze aversion, gestures). A responsive environment on trains should be designed to permit both states of togetherness and isolation, since some people want to be isolated and others want to be in contact.

2.4.5 Playing Games

OVERVIEW

Games are one way of keeping occupied on a long train ride. This section reports the opposing findings of a study by Wichansky (1979) and a newspaper article on games on planes and trains.

REVIEW OF THE RESEARCH

Offering passengers games to play is becoming a new attraction on some public transportation systems. Games relieve boredom on long journeys and are a good public relations or selling feature. For example, CP Air now offers passengers video games on its Vancouver-to-Amsterdam flights, with the assistance of Air Video, Inc. of Toronto and Altus Corporation of San Jose, California, who supply games (The Globe and Mail, August 4, 1983). Recently, passengers on CP Air's Vancouver-to-Toronto flights have been given video game trays as part of a one-month experiment during which the two manufacturers are vying for a contract with the airline.

Response to the game trays has been positive among passengers on the Amsterdam trips. If public response is also good after the Toronto-Vancouver experiment, CP Air may consider permanent sets built into trays to replace the portable units used now.

For the business traveller, the game will contain a mini-computer with nine financial programs, a sports game, and a blackjack game. For other passengers, there will be a selection of sports games, games of chance, and hand-eye coordination games.

Offering passengers pasttimes such as games to keep them occupied on a train journey can relieve tension, reduce boredom, facilitate privacy regulation (see Koneya, no date), and distract passengers from on-board environmental stresses such as noise and vibration.

However, Wichansky (1979) found that games are among the least popular passenger activities on Amtrak trains, accounting for only 1.3% of all observations. Games were considered to be unimportant by the greatest number of respondents (82.7%). The Wichansky study, however, predated the recent boom in video game popularity, and did not include children or adolescents in the interviews.

CONCLUSIONS

Video games are a popular new attraction on CP Air flights (The Globe and Mail, August 4, 1983). However, in a study of passenger activities on trains by Wichansky (1979), games are listed among the least popular of passenger activities.

In conclusion, it is suggested that the popularity of games on train trips has a lot to do with the type of game offered. Traditional board games are likely unpopular because of their already high exposure, while video games, because of their novelty, are probably more popular.

2.4.6 Sightseeing (Looking Out the Window)

OVERVIEW

Sightseeing or looking out the window is engaged in by many train passengers on long journeys because there is often nothing else to do. However, it is also a valued activity in its own right.

This section reports the relevant findings on sightseeing from two studies on passenger satisfaction in plane and rail travel.

REVIEW OF THE RESEARCH

In a study of passenger satisfaction on plane rides, Jacobson and Martinez (1974) found that viewing or looking out the window was the third most important factor to passengers, after reading and thinking.

Wichansky (1979), in a study of passenger activities on Amtrak trains, found that viewing was the most popular activity, accounting for 24.9% of all observations. Viewing activity was particularly high during periods of acceleration and deceleration of the train, or when there was some change in motion.

One of Wichansky's recommended improvements in present or future train service is to keep windows clean and make sure all lights are working, since many passengers value viewing inside and outside the train.

CONCLUSIONS

Looking out the window is a valued pursuit by both plane and train passengers. It is a calming activity on a long journey and is a valid alternative to work activities, such as reading and writing. In fact, Wichansky (1979) found that viewing is the most popular activity on Amtrak trains.

2.4.7 Working

OVERVIEW

In the section on Reading (2.4.3), research by Wichansky (1979) and others was reported on the importance to passenger comfort of work activities like reading and writing on train journeys. This section reports an article (no author, November, 1982) describing the work facilities on Danish State Railways' new "Lyntog" ("Lightning") train.

REVIEW OF THE RESEARCH

In 1982, two prototype trains of Danish State Railways' new "Lyntog" ("Lightning") stock went into service on the Copenhagen-Aarhus route (No author, November 1982). The train has several innovative features, including vacuum-operated toilets, provision for the disabled, and on-train meeting room facilities.

The "driving trailer" incorporates seating for 74 passengers arranged in face-to-face fashion across central tables. This allows for conferences and ease of discussion.

The first class coach provides six seats each in ten compartments. A large table and waste container are attached to the outer wall of each compartment, and the corridor seats have small pull-out tables for working. At one end is a toilet.

The service coach has a service area including a refreshment facility, and a two-seat compartment for train personnel equipped with a public address system. The vehicle also has three compartments divided by folding partition walls. The compartments can be thrown together for on-train meetings, and fitted with loose tables and chairs, or for conventional service, with fixed facing seating for 22 passengers. Typewriters, slide projectors, and other equipment can be borrowed on application from the train stewardess.

These facilities will aim to accommodate travelling business people who want to work on the train, either singly or in groups.

CONCLUSIONS

Working during a trip is important to many train passengers. The new 'Lyntog' train of Danish State Railways offers comfortable work facilities for passengers, including seating face-to-face across central tables, allowing for conferencing. A large table is attached to the outer wall of each of ten first class compartments. Typewriters, slide projectors, and facilities for on-train meetings are also available.

However, it might also be beneficial for trains to have reading and writing facilities for single as well as group passengers, including writing trays attached to the seat that can be folded up, and perhaps a small on-train library or magazine rack.

2.4.8 Self Care

Panero and Zelnik (1979) and Diffrient et al (1979) provide basic ergonomic data to guide designers. Panero and Zelnik even specify relevant dimensions for changing areas, toilets, beds, eating spaces, etc. The tasks of integrating all of these activity spaces into a compact space, such as a train roomette, is a difficult one.

Compromises must be made between providing optimal space and using space economically. This will require considerable research into both passengers' physical attributes (e.g. what % of train riders are over 190 cm tall?) and their preferences (e.g. would passengers rather have more floor space or easier access to luggage?).

2.4.9 Care of Travelers with Special Needs

OVERVIEW

Like most other facilities in public life, transportation systems are designed for healthy, agile people with full use of their limbs and sharp senses - i.e., the young. Elderly people, pregnant women, and handicapped travelers contend with reduced mobility due to poor senses and reduced use of limbs.

The research reported here describes the difficulties which the elderly and the handicapped have in using transportation systems such as trains. Also described are hardware innovations, such as wheelchair restraint systems, for making their trip safer and more comfortable.

REVIEW OF THE RESEARCH

The organism can respond directly only to those aspects of the environment experienced through the sense organs. Therefore age changes in sensory organs "affect" the world in which the elderly person lives. Pastalan (no date) constructed a simulation model to duplicate relevant environmental experiences of a person in his late seventies.

Hearing loss for the elderly usually occurs above the 2,000 Hz. range and decibel loss averages around 30 for those people 65 years or older. Other senses - for the aggregate group, even if not for specific individuals - begin to fail with old age as well. Pastalan developed devices - ear plugs, coated lenses, cotton wadding, liquid fixative - to simulate age-related hearing loss, eyesight loss, olfactory loss, and tactile loss respectively.

The research team included four doctoral students who experienced three settings using the simulation devices: a dwelling unit, a senior centre, and a shopping centre. Each subject kept a record of his experiences for one hour a day for six months.

Glare from uncontrolled natural light and from artificial light sources was the worst difficulty encountered. If only a single intense artificial light source is used for illumination rather than several, the chance of uncomfortable glare is increased. Another problem was contouring, the capacity to perceive the boundary between two contrasting surfaces (especially when two intense colours such as red and green bounded each other). The boundary appears visually unstable and appears to shift. This is a hazard when an elderly person tries to negotiate stairs or distinguish floor from wall surfaces. A third problem is disappearance of boundaries. Closely related colours tend to fade and blend into each other. This also creates problems in distinguishing wall and floor surfaces, and stumbling into walls is common.

There was difficulty in eye recovery moving from a lighted area to a dark area or vice-versa. The sudden movement from an area having too much light to one having too little should be mitigated with transitional lighting arrangements. Also, dark wall surfaces bounded by windows admitting sunlight make it difficult to see objects near the walls. Extremes in contrast needs to be reduced. Ability to see fine visual detail such as printed information and directional signing was badly impaired.

There are design implications of these findings for trains. A continuous overhead lighting arrangement should be used so that all parts of the passenger car are illuminated and so can be distinguished. Signs should be illuminated so they can be seen clearly by elderly pasengers.

Other pertinent findings of Pastalan's study are that the ability to hear (conversation, background noises) is reduced. Perception of odors is also significantly reduced. These results have fewer design implications for passenger railway cars than do the findings on eyesight. However, many public address systems are often difficult to understand even if your hearing is normal.

Stoudt (1981) points out that the people over 65 years of age are, as a group, signficiantly smaller in body size than younger adults. Elderly males, aged 65-74 years, are on average 2.4 inches (6.1 cm) shorter and 1 pound (.45 kg) lighter than the youngest age category of adults. Elderly females are 2 inches (5 cm) shorter but 14 pounds (6.4 kg) heavier than younger female adults.

Certain other kinds of specialized body measurements are required for practical design applications for the elderly. Train passenger seats are a good example. Ideally, the dimensions of some train seats should be altered to match the different body dimensions of the elderly and so accommodate them in comfort. See the tables, "Body Dimensions of Elderly Males" and "Body Dimensions of Elderly Females" (Stoudt, 1981), reprinted below.

Another specialized group of train passengers are the handicapped. Feeney, Ashford, Morris and Gazely (1979), in a survey of fourteen organizations for handicapped people, found that the main problems experienced in using public transit are in relation to level (steps, curbs), the lack of suitable provision of grab rails, and the position and characteristics of seats within vehicles. Road crossings, car parking and distance to transport facilities were also mentioned.

In a behaviour study, the same authors observed and recorded on film a wheelchair user, a spastic, an elderly person, and a non-impaired mother with a child in a pushchair. The wheelchair user experienced fewer difficulties than most other subjects because she received more assistance during travel!

Raising and lowering the body through a change of level was one major travel task which presented difficulty for all the subjects. Provision of adequate handholds was found to be important for raising the body during vehicle access, especially when the lower limbs are impaired.

In addition, Feeney et al (1979) interviewed 166 physically disabled travellers and 29 physically disabled non-travellers. Trains were used by 10% of the travellers, and buses by over 50%. Results showed that bus drivers could assist the handicapped traveller by making sure the vehicle stops as close to the curb as possible and remains stationary until the passenger is seated.

For rail travel, facilities which could be beneficial to disabled passengers often exist but their use is sometimes hampered by travellers lack of knowledge of these facilities. For example, some trains on the Norwegian State Railways have wheelchair lifts which raise a wheelchair using passenger onto the train from the station platform. There are occassional instances where it is so awkward or demeaning to access services that wheelchair users would rather find alternative procedures to those provided by the system operators.

Among train users, the main problems were platform access (steps and stairs) and carriage access (step height, lack of handholds, and door widths). Clearly, special design accommodations are needed to train stations and the railway cars themselves to ensure adequate access for disabled train travellers. Probably electric wheelchair users present the biggest design difficulties.

Vast embarrassment recently was heaped on VIA Rail when a well-known handicapped activist was denied the right to travel with his electric powered wagon. The newspapers covered the story of John Kellerman's trip to Ottawa on Air Canada. This activist is a former staff member of Behavioural Team - but perhaps we should not admit it.

Some trains do have special design features for the disabled. For example, the Norwegien State Railway (NSB), as part of its policy of improving travelling conditions for the handicapped, mothers with babies, and others who require special facilities, is building thirty railway cars designed to accommodate these passengers (no author, October 1978). The first of these cars is now in service on the Oslo-Bergen line.

There is provision of 1500 mm. wide access doors for wheelchairs, but otherwise the exterior of the car is conventional. Overall length is 23.9 m. and there are standard vestibule doors at each end. The interior compartments are arranged to accommodate mothers with infants, disabled persons in wheelchairs, and stretcher users. One compartment for the disabled has seating for eight, but the four seats closest to the window are removable to allow space for two wheelchairs. Double sliding doors provide good access from a 850 mm. wide corridor. There is a toilet adjacent to this compartment with entry from the corridor through a door 1000 mm. wide to allow wheelchair access.

Lift platforms have been installed which can raise a wheelchair (or luggage) from ground level. At the centre of the car is a luggage vestibule. The luggage area is equipped with oxygen apparatus and a stretcher. A small wheelchair for use when a disabled passenger wants access to the restaurant or any other part of the train is kept there. Opening directly off the luggage vestibule is a compartment for stretcher users, with space for four seats, or one stretcher and two seats.

Heron (1980) describes the prototype of a wheelchair restraint system developed for use in trains as a step toward increasing the transportation mobility of the handicapped. It was tested under normal operational conditions on an inter-urban train run. The system consists of a welded steel frame with a moulded plastic shell and an upholstered back and headrest.

Two performance tests for 12 male and 8 female disabled volunteers were used. One test covered tasks for getting into the device, the other covering tasks for getting out of it. Responses to a questionnaire indicated that the restraint system offers a maximal sense of security. No subject reported experiencing vibrations.

Six subjects indicated a preference for the regular passenger seat, due to the desire to avoid isolation. All but three subjects gave the system the highest possible rating for appearance. Maneuvering in was found difficult by almost all subjects. It required moving backwards and attempting to center the wheelchair against the device without cues. A centering stripe on the floor is suggested.

Belt operations were also experienced as difficult as were tray operations (a tray for eating and drinking is stored in a compartment behind the headrest) due to weakness in the subjects' upper limbs. Subjects also had some difficulty with belt operations due to upper limb weakness.

The evaluation succeeded in pointing to relatively minor design changes which would make the system usable by wheelchair users who may have weakness in the upper limbs and suffer from spasticity as well. Paraplegics could also operate the system in an independent manner. On the other hand, severely disabled individuals would require a full-time attendant. In sum, the device is an ergonomically sound advancement which will open up the possibility of rail travel for physically disabled individuals.

Body Dimensions of Elderly Females (From the U.S. Health Examination Survey, 1960-1962[1])

Dimension	Age	Mean	Percentiles								
			1st	*5th*	*10th*	*30th*	*50th*	*70th*	*90th*	*95th*	*99th*
Weight[2]	65–74	144	90	104	112	130	143	158	181	194	212
	75–79	136		93	103	117	135	153	176	191	
Height[3]	65–74	61.5	55.8	57.5	58.3	60.2	61.6	62.8	64.7	65.5	67.0
	75–79	61.1		55.3	57.3	60.1	61.8	62.8	64.5	64.9	
Sitting Height Erect	65–74	32.1	28.6	29.7	30.3	31.5	32.2	32.9	33.9	34.5	35.8
	75–79	31.7		28.1	29.2	31.1	32.1	32.8	34.0	34.8	
Sitting Height Normal	65–74	31.1	27.0	28.7	29.3	30.4	31.2	31.9	33.1	33.9	34.9
	75–79	30.5		27.1	27.6	30.1	31.0	31.8	32.8	33.4	
Knee Height	65–74	19.3	17.1	17.8	18.1	18.7	19.2	19.8	20.7	21.0	22.0
	75–79	19.4		17.3	18.0	18.9	19.4	19.9	20.7	20.9	
Popliteal Height	65–74	15.3	13.0	13.9	14.1	14.7	15.3	15.9	16.8	17.0	17.9
	75–79	15.5		13.5	14.1	15.1	15.6	16.2	16.9	17.2	
Elbow Rest Height	65–74	8.4	5.4	6.4	7.0	7.8	8.5	9.1	9.8	10.2	11.3
	75–79	8.2		6.4	7.0	7.7	8.4	9.1	9.8	10.0	
Thigh Clearance Height	65–74	5.3	3.4	4.1	4.2	4.9	5.3	5.7	6.2	6.6	7.0
	75–79	5.2		4.0	4.1	4.7	5.2	5.6	6.1	6.5	
Buttock-Knee Length	65–74	22.2	19.4	20.2	20.6	21.5	22.2	22.9	23.9	24.6	25.9
	75–79	22.0		19.9	20.3	21.4	22.2	22.6	23.5	23.9	
Buttock-Politeal Length	65–74	18.8	16.1	16.9	17.3	18.2	18.8	19.4	20.4	20.9	21.9
	75–79	18.6		17.0	17.2	18.0	18.7	19.3	19.9	20.0	
Elbow-to-Elbow Breadth	65–74	16.4	12.4	13.7	14.2	15.5	16.4	17.4	18.8	19.7	20.8
	75–79	15.8		13.1	13.5	14.7	15.7	16.9	18.1	19.1	
Seat Breadth	65–74	14.7	12.1	12.4	12.9	14.0	14.6	15.4	16.7	17.3	18.2
	75–79	14.2		11.7	12.2	13.3	14.0	15.0	16.5	16.8	
Biacromial Diameter	65–74	13.7	12.2	12.5	12.8	13.3	13.7	14.0	14.7	15.0	15.7
	75–79	13.6		12.5	12.8	13.3	13.6	14.0	14.6	14.7	
Chest Circumference	65–74	35.7	29.0	30.9	32.2	34.2	35.7	37.2	39.8	41.0	42.2
	75–79	34.8		30.1	30.6	33.1	35.0	36.1	39.0	39.9	
Waist Circumference	65–74	33.1	24.4	26.3	27.7	30.2	32.9	35.3	39.3	40.7	43.5
	75–79	32.8		25.9	26.6	30.7	33.2	35.2	38.8	39.9	
Right Arm Circumference	65–74	11.5	8.2	9.2	9.8	10.9	11.5	12.4	13.5	14.0	15.3
	75–79	11.0		8.4	8.9	10.1	11.0	12.1	13.3	13.8	
Arm Fatfold	65–74	2.4	0.8	1.2	1.5	2.0	2.4	2.7	3.4	3.6	4.7
	75–79	2.0		0.7	1.0	1.7	2.2	2.5	3.1	3.3	
Subscapular Fatfold	65–74	2.0	0.6	0.8	1.0	1.6	1.9	2.5	3.4	3.6	4.1
	75–79	1.7		0.5	0.6	1.1	1.7	2.1	3.0	3.6	

[1] Stoudt Damon McFarland and Roberts 1965 1973

[2] Weight in pounds nude corrected for clothing

[3] Height and all other dimensions in inches

Note Customary rather than SI units are presented in this table as the information is taken from a previous publication

Via Rail has a policy of carrying all types of passengers, including those with special needs. These include the very young and senior citizens, obese, arthritic, epileptic, mentally retarded, pregnant women, and the non-ambulatory. A passenger's special need is a function of his/her physical disability as well as a function of the passenger's ability to cope with varying situations, and the type of services potentially available. Five percent of the U.S. and Canadian populations have difficulty using public transportation.

VIA Rail Canada works closely with special needs consumer groups and is a Canadian leader in the development of effective approaches to the problems of passengers with special needs. VIA's policy is to provide transportation and related services to the public without exception, subject to space availability, safety, and an acceptable degree of passenger autonomy. Through this policy VIA offers services to a wide cross-section of the public. VIA's program is aimed at ensuring the human needs of its disabled passengers, including personal dignity and sense of independence. But, as with other large organizations, there may be discrepancies between managerial wish and personnel realities.

VIA devised a checklist to identify the requirements of each of the various handicapped groups, utilizing each of 35 major services offered by VIA (e.g., food and beverage, luggage handling) in three categories of VIA locations (station, train, corporate offices).

When VIA was first established in 1977, the services and facilities which it inherited were not designed to meet special needs consistently. To apply VIA's policy of carrying all passengers, a program for passengers with special needs was developed. This program can be divided into "immediate measures" to be implemented in 1980 and a "five year plan" to be implemented from 1981 - 1985.

As part of the "immediate measures" a special VIA Committee on the Handicapped was set up, with representatives from each VIA department. This committee provides a mechanism for determining the feasibility of proposed improvements. In addition, an expert in the field of transportation for the handicapped has been retained to manage and coordinate the program. Also, a program to increase public awareness of VIA's services for special needs has been set up. This program includes the preparation of brochures in regular print, large print, and braille. In addition, VIA implemented a program to provide manual lifting onto trains at thirteen major stations. Workshops were held for redcaps at these stations to guarantee that manual lifting could be effectively provided.

Design considerations have been addressed to modify ground-based facilities to accommodate passengers with special needs. These design considerations were organized under the following headings: exterior access, horizontal access, vertical access, various facilities, and general considerations. Station access is also being improved by increasing the supply of wheelchairs available at stations. Also, a variety of measures are in progress to improve access to trains, including station and train-based lifts. Also wheelchair restraint systems have been modified to fit VIA Rail trains. There has been an installation of new equipment in a system which enables VIA to communicate with passengers who have speech or hearing problems.

For the Five Year Plan, the management structure set up under the "immediate measures" will be maintained. The public awareness program will be continued and expanded. Also, a public information package, consisting of brochures, posters, and articles in publications was to be designed in the first year of the plan. Employee training involves development of procedure manuals, as well as a sensitivity/technique training package. Based on a comprehensive checklist of potential difficulties, procedures will be developed through which VIA employees will provide special assistance. In addition, modifications to station access will be made such as automatic doors, accessible washrooms, rest areas, handrails, standardized step heights, curb cuts, elimination of grade changes, and elimination of hazards to the sight impaired.

Lifts for intercity trains will be tested and 250 will be purchased and installed on these trains. Forty lifts will be installed on long-distance trains. Some 250 modified wheelchair restraint systems will be installed on trains. Accessibility requirements will be designed for long distance trains to address food service, washroom, sleeping accommodation, and movement. Finally, twenty station-based lifts will be installed at major stations.

CONCLUSIONS

The elderly and the handicapped are two groups which, because of their infirmities, need special facilities and help on trains. Pastalan (n.d.) found that glare from uncontrolled natural light and from unbalanced artificial light sources are the worst difficulty related to sense organ deficiencies in the elderly. This suggests a need for even, moderate lighting on trains, as well as blinds on the windows. Stoudt (1981) points out that elderly males and females are several inches shorter than younger adults. Several seats with smaller dimensions - especially a lower headrest - would be of benefit to elderly passengers, children, or other short persons on trains. However, Wachs argues that the transportation of the future elderly will be the automobile, even though his study included only the car, taxi, and bus as modes of transportation, and did not deal specifically with long distance trips.

A major transportation problem for the handicapped is raising and lowering the body through a change of level. The problem of negotiating steps and stairs is especially acute for wheelchair users. Some trains, however, do have wheelchair lifts, which raise the wheelchair and its passenger onto the train from the station platform through wide access doors. Wheelchair restraint systems which restrain the wheelchair to the floor or wall are another innovation for the accommodation of the disabled on trains.

Via Rail has instituted a policy of carrying all members of the public on its trains, including the handicapped such as the non-ambulatory, obese, pregnant women, the very young, and senior citizens. This policy can be divided into "immediate measures" for 1980 and a "five year plan" for 1981 - 1985. The immediate measures include hiring a special "transportation for the handicapped" expert, setting up a public awareness program, a program to provide manual lifting onto trains, and corresponding training workshops for redcaps. Design modifications to stations have also been implemented and more wheelchairs at stations have become available. For the "five year plan" the public awareness program will be expanded, a public information package, consisting of brochures and posters will be begun, employee training in sensitivity/technique will be implemented, and station access improvements will be made.

2.4.10 Sleeping

OVERVIEW

Passengers on a long train journey are likely to fall asleep several times. Some of this sleep may be in the form of short naps. But for overnight periods, most passengers prefer a comfortable resting place [illegible] an extended period of uninterrupted sleep.

Factors which may promote or interfere with sleep vary between individual people. Variations in the individual's state, such as the level of weariness or anxiety, are also important. Loss of sleep, or even perceived loss of sleep, can have negative effects on many of the passenger's other attitudes and behaviours.

REVIEW OF THE RESEARCH

The research on sleep is quite extensive, with several entire journals devoted to the topic. Both normal and pathological sleep have been subject to extensive study. The techniques involved in studies of human sleep include questionnaires, behavioural observations, and physiological studies. Our understanding is also enhanced by thousands of studies of sleep in other mammals. These animal studies help to uncover the role of different areas of the brain and various neurochemicals in the regulation of sleep.

Most of the research on human sleep has involved paid subjects studied in special "sleep labs." The researchers generally look at long periods of sleep (usually overnight) after the subject has adapted to the novel environment. There is little research on short naps, or on the first few nights of sleep in a new place. Unfortunately, these are the features that characterize sleep on the train. These times have not been studied because there is so much variability in sleeping behaviour for naps and new settings.

In terms of overnight sleep, people who characterize themselves as poor sleepers differ in several respects from people who think that they are good sleepers. In a report on these differences in US Navy sailors, Johnson and Spinweber (1982) conclude that poor sleep is associated with other psychological problems such as anxiety and self-doubt. This massive study looked at all sorts of data about sleep and its effects. Although it deals with a relatively homogeneous group of healthy young men, there are still significant sleep problems. Similar problems can be found among the rest of the adult population.

Some poor sleepers may take longer to get to sleep than people who are good sleepers. But most poor sleepers overestimate the time it takes them to fall asleep. Good sleepers' estimates average less than 20 minutes and poor sleepers claim it takes them over 60 minutes. In the laboratory, however, most of the "poor" sleepers fall asleep within 30 minutes. Of course, in sleep lab studies there are few unpredictable distractions which might interfere with falling asleep. But poor sleepers do not differ from good ones in feeling that they are easily awakened by noise. Some of the poor sleepers do take longer to get to sleep. However, they do not differ from the others who claim to be poor sleepers on sleep complaints, mood questionnaires, or long-term performance.

Poor sleepers have a variety of sleep complaints besides taking a long time to get to sleep when they go to bed. They feel that they awaken more times during the night and take longer to fall back asleep. They have a harder time getting out of bed, and don't usually feel well rested in the morning. In terms of mood variables, poor sleepers are more tense, depressed, angry, tired and confused. The good and poor sleepers do not differ on any electrophysiological (EEG) measure of sleep, except that some do take longer to fall asleep initially.

It is important that train passengers be assisted to have a good night's sleep if they are there during their normal sleeping time. Feeling that you've had an adequately restful sleep is the main criterion for sleeping accommodations. Unfortunately, some people are likely to have sleep problems regardless of the comfort and quiet of the sleeping environment. Others, who ordinarily sleep well, may have some problem on the train because it is a new setting. Hopefully, few passengers will have trouble sleeping due to noise, vibrations, accelerations, temperature or light extremes, uncomfortable beds or reclining seats, or activities of crew and other passengers.

Much of the other sleep research deals with the effects of loss of sleep on work performance. Although train passengers do not necessarily have to perform a high degree of physical or mental work, mood and satisfaction are affected by sleep loss at a much lower threshold. Any sleep loss, real or perceived, should be avoided. This may require more individual treatment of passengers with regard to things such as preferred awakening time.

More research should be done on the sleeping patterns and attitudes of long distance train passengers. Repeat riders might have a good idea of the accommodation they require to sleep overnight on the train. They could provide information on things that pose consistent problems in sleeping in various accommodations on the train. Some simple questions might be developed to help new passengers decide which type of accommodation will meet their sleep requirements.

CONCLUSIONS

Some people can fall asleep almost anywhere and any time. Others may have specific environmental and social requirements. For instance a small child in a novel enviroment may require a known adult, a night light, their pillow from home, and no strangers conversing nearby. Other people may have a hard time getting a good night's sleep no matter what. But most people can get a satisfactory overnight sleep in one of the kinds of accommodation offered.

Some passengers will be willing to pay more for more comfortable sleeping. This can be related to physical comfort of the substrate - a bed instead of a day-niter - or to psychological comfort - a private place to sleep unwatched. Both design and operational considerations can lead to better passenger sleep. However, little is known about what makes for good versus poor sleep among long distance train travellers.

2.4.11 Intimate Social Behaviours (Both Positive and Negative)

On a long train trip, behaviours that might otherwise take place in the home among friends or family members, can occur within hearing and/or sight of other passengers. Arguments, fights, care and affection, and even sexual activities may occur without apparent regard for the sensibilities of other passengers. Social responses in these situations are variable. In most cases, minor incidents are merely ignored. However, some passengers may occasionally feel compelled to complain to the offending parties or to one of the train crew. This can result in awkward situations, but crew must be prepared to deal with such issues as public drunkeness, child abuse, sexual harassment, etc.

The design of passenger accommodation should take these unpleasant or annoying social situations into account. For example, it would not be a good idea to make a passenger coach too quiet, because then you could hear every whining child and every panting young couple. The background noises provide some privacy by masking the sounds that the materials don't absorb. As another example, the sound insulation between the bedrooms and in the sleeping car corridors should be good enough to provide a quiet night and keep the sounds of snores and copulation from disturbing the people in the next roomette. But it should not be so soundproof that a life threatening emergency could go unnoticed. This may mean that some very loud snoring, arguing, or enraptured moans will be heard in the next room. But then a knock on the wall could also be heard by the noisy party.

2.4.12 Smoking

Although smoking is an important activity to some train passengers, there seems to be little research on the ergonomic aspects of this behaviour. Several articles mention the provision of ash trays in seats, "no smoking" sections, or fire retardant construction materials. However there seems to be little research that deals with issues such as train passengers' preferences as to when and where they smoke, movement of smoke odours within passenger compartments, different effects of pipes, cigars and cigarettes on non-smoking passengers, social facilitation of smoking in public places, etc.

Smoking also has several maintenance implications. These range from emptying ashtrays and discouraging their use as waste bins, to cleaning the inside of windows more frequently where they are exposed to cigarette smoke. Smoking is obviously a problematic area involving issues of health, safety, comfort, and individual rights. It clearly deserves more consideration and study in the passsenger train environment.

2.5 Transitions Between Accommodation Space and Public Space

OVERVIEW

On longer journeys more passengers will leave their seat or room to use some other space on the train. A brief excursion might involve merely standing in the aisle and stretching. A longer absence from the accommodation space might involve a visit to the washroom, bar car, snack bar, or observation area, or just a walk to one end of the train and back.

The human factors issues involved in this transition from accommodation space to public space fall into two main areas - getting up from your seat or berth and going through doorways. Aisles are described in the next section.

REVIEW OF THE RESEARCH

Getting into and out of seats has been studied on buses (Brooks et al, 1980) but not on trains. The work on passenger buses indicates that most problems come from jerky accelerations and inadequate handholds. Elderly and disabled passengers have more problems in these areas. Women also seem to be overrepresented in accidents in the aisles. This may be due to less stable footwear (i.e. high heels).

On trains there are fewer and less jerky accelerations so the potential for passenger accidents is less. It might be helpful to provide some signal to passengers at those times when the train is going to start, stop, or change speeds, since unexpected accelerations are more likely to cause a loss of stability in a passenger who is getting up or standing. Luggage is more of a problem on trains than in buses, and can significantly interfere with getting into and out of your seat (Williams, 1977).

The results of research on buses (Brooks et al, 1980) demonstrate the need for handholds when changing levels. This is important not only for boarding, alighting, and climbing stairs, but also for sloped gangways and getting into and out of seats. Most passengers use their hands in some manner, especially when getting up from a seat. The armrest and the seat in front are often used to help push or pull the weight of the arising passenger. This factor seems not to have been included in any ergonomic tests of seat design. Additional attention to this detail will be particularly helpful to elderly persons or others with physical limitations (e.g. someone who is pregnant or wearing a cast.) The use of molded plastic housings for rail passenger seats permits simple handholds to be incorporated without creating protrusions.

The doors on the train can cause other problems in going from one space to another. The general problems with door use have been reviewed recently in several articles (Seaton, 1980, 1981; Johnson, 1981.) These studies are based on observation of door use in both laboratory and field settings, and review of accident statistics involving doors. The most common door accidents (about 50% in one study of over 6,000 incidents in hospitals) involve getting some body part in the way of a closing door. The other half involve running or falling into doors, falling while going through a door, or being hit by a door that someone else is opening.

Besides accidents, other door problems include inadequate space for opening or passing the door, mistakes or physical difficulties in operating the door, difficulty opening doors while carrying things, and automatic door closers that are too fast or too strong for disabled persons. All of these iisues demand consideration in the design of doors on the train.

If the doors between cars are of the automatic sliding variety, with sufficient width, many problems are avoided. The door can not be pushed or pulled the wrong way unless it is already inoperable. The activating sensors usually prevent the door closing on a body part, and compressible edges and special edge sensors can preclude possible injury. You have to run very fast to run into the door. And opening these doors is no additional problem for people using crutches or carrying baggage or babies.

Non-automatic or self-closing sliding doors might be advantageous for entrances to washrooms and roomettes. They are common in many state-of-the-art yachts (personal observations, 1983) because they don't interfere with passenger space. You can't bang the door into someone standing on the opening side, and you don't have to fold up the bed, move the chair, etc. to get the door fully open.

A newly developed door for the Mk-3 British Rail coach addresses many of the human factors considerations for swing-plug doors (Ford, 1983). These are external doors but many of the same issues hold for interior doors. The new Mk-3 door is a significant improvement over the earlier version. In a rare example of awful human factors, the old door required passengers inside to open the window and use the outside handle to open the door. The new door has more well designed operating features, and an automatic closing mechanism that precludes injuries from passengers being pushed by or caught in the door.

CONCLUSIONS

In moving from an accommodation space to a public space and back, several human factors issues arise. Difficulties are greatest for disabled people or those carrying things. Attention to the requirements of different people in the design of handholds and doorways can make things more easy, safe and pleasant for all passengers.

2.6 Activities in Common or Public Spaces

2.6.1 Aisles

OVERVIEW

This section deals with passenger flows in crowded spaces. The space or passenger flow required to cause congestion can be calculated using statistical techniques or theoretical models. These are the two methods used in the papers on congestion and passenger flow by Stilitz (1969) and de Neufville and Grillot (1982) reviewed below.

These papers do not deal directly with passenger flow in trains, but the issues raised are relevant for train areas such as aisles between seats, corridors in sleeping cars, and standing queues at food service areas.

REVIEW OF THE RESEARCH

In a study of pedestrian groups in crowded spaces, Stilitz (1969) made informal observations in congested locations: concourses, markets, department stores, etc. He states that space of given absolute dimensions may permit a variety of pedestrian passenger movements and of levels of comfort. Only a small number of possible configurations will allow optimum rates of flow and minimal personal interference. Observations suggested that groups of static pedestrians play an important role in determining patterns of flow. These groups were chosen for more formal study.

The aim of a subway ticket hall study was to describe the major static groups that occurred within the space such as queues and groups of people around the automatic ticket machines. This description was to relate the physical attributes of the space and to determine qualitative effects of static groups on movement and congestion in the space. Observations were done during rush hour when the subway ticket halls are highly used. Observations were made on five ticket halls on the Central Line in London.

A simplified plan of the ticket hall was drawn on graph paper. Queue location was recorded by drawing lines of appropriate length. Locations of people, ticket machines, and other static groups were drawn by lines which enclosed all the people in the group when it was observed. Flow routes were recorded every ten minutes over a forty minute period.

Queues occasionally formed an obstruction to passing flows. This happened when the queue length was greater than nine metres. Waiting people who were not buying tickets had little effect on the flow. The line of flow of queues tended to block up entrances that feed them. When people passed through the queue they often came into bodily contact with those in the queue. Interference starts when the queue is greater than approximately 4.5 metres long. Beyond this point, about one person per minute passes through per metre length of queue. Waiting pedestrians usually choose locations which are protected from passing flows and which allow them to see and be seen.

De Neufville and Grillot (1982) did a study of congestion in airport terminals. Areas subject to interaction between flows and queues of passengers waiting for service, such as lobbies in front of ticket counters and baggage claim areas, are very sensitive to congestion. They state that the problem with current design procedures for airport terminals is that space requirements are determined according to the criterion of average space per person instead of focusing on critical locations. The result is that space may be misallocated and capacity of the terminal may be determined by a small portion of the terminal, leaving ample room elsewhere.

The standard procedure for determining space for passenger areas in airport terminals is planning a fixed amount for each typical peak hour passenger, depending on the type of facility. It is wrong to allocate space using averages. The loads on any particular facility need to be taken over its critical (congestion) period.

The method consists of four analyses to be applied to any potential trouble spot for pedestrians:

1. estimate of the loads on the space, taken over the congestion period,
2. calculation of the width of the passageway needed for pedestrian flow,
3. calculation of the range of queue lengths and areas at service facilities,
4. integration of the last three steps into a complete analysis of the flows and queues at the potential trouble spot.

This model can be used to calculate the width of the passageway needed to accommodate a given flow, or to check whether an existing passageway has enough space so that, for example, handing out leaflets would be possible.

CONCLUSIONS

Stilitz (1969) discusses obstructions of queues due to passing flows of pedestrians. When people are entering a train and moving down the aisle to find seats, others already seated who are trying to leave the train will be obstructed. Likewise, a queue at a snack bar on the train will interfere with other passengers passing through the same aisle.

De Neufville and Grillot (1982) describe a model for determining space for passenger areas in airport terminals. The model can be used to calculate the width of a passageway needed to accommodate a given flow. Similarly, the model might be used to calculate the preferred width of aisles in bar cars, based on peak loads.

2.6.2 Washrooms, Toilets

The most commonly employed method for determining the use of washroom facilities is that of observation. The purpose of these observations is to obtain data that could be used to evaluate plumbing fixture requirements and to aid designers in estimating the number of fixtures used.

One type of observation involves observers standing some distance from the washroom entrance. The observer can note the person entering and leaving the washroom and record this information on a small unobtrusive tape recorder. From these observations, the inflow and outflow of people, the number of persons in the washroom at one time, and the mean duration of time spent inside can be obtained.

Observations can be made in a similar manner inside the washroom and data collected to estimate duration and frequency of facility use. For example, by multiplying the frequency by the duration of use, a measure of fixture demand can be obtained.

It should be noted that studies of this sort have been conducted in buildings and not on moving vehicles.

Results of a pilot study (McClelland, 1982) indicated that the range of heights for a toilet seat found to be comfortable was from 0.30m to 0.50m. The range of angles found to be comfortable was between -6 deg and +6 deg relative to the horizontal. The results of this study also indicate that seat angle does not have any effect on preferred seat height. In addition, the height of the front edge of the seat was an important cue for subjects when assessing seat height.

The results of a more detailed study by the same author involving 205 subjects, which was representative of the general adult population of the United Kingdom according to demographic data, suggest that a seat height of 0.40m is the preferred height to accomodate most users.

The author recommends that further investigations be made into developing a greater variety of seat configurations, including models that provide for both buttock and thigh support.

2.6.3 Lounges, Snack Bars and Restaurants

OVERVIEW

The contribution made by George Mortimer Pullman established quality railroad dining car service many years ago. It was not until aftr W.W.II that rail lost its biggest customers: the personal traveller, who found their cars more enjoyable and the businessman who used the plane for speed. A loss in profit forced the railroads to cut back. In turn, the quality of rail catering was affected. Today the need for improved food service on trains is as pressing as ever.

Food service in transportation is subject to prejudices based on personal preference. It is important to determine to what extent modifications of food services can influence passengers' responses to rail transportation.

It is agreed (Tennyson, 1976; Graham, 1976) that the distance to be travelled often determines the type of food service required. Snack bar facilities with beverages and packaged foods are particularly suited to small, moderately patronized trains. A fast-food type service with some seating is best for medium volume patronage. For long distance travel, where patronage and timing permits, the full traditional dining car service should be upheld.

REVIEW OF THE RESEARCH

George Mortimer Pullman (1831-1897) provided a significant contribution to quality railroad dining car service (Dublin, 1976). Initially, travellers would hastily take their meals at the various eating houses enroute to their destination. Streichardt (1981) mentions that in the traditional post-coach style, the "Stop and Eat Here" sign was put out and it was a matter of buying your own lunch.

During the 1860's simple meals were being served aboard the "steam cars." At this point though, quality restaurants-on-wheels, where the "haute cuisine" was served in saloon cars with wooden tables, did not exit (Dublin, 1976).

In 1867, Pullman produced the first luxury car combining both sleeping and eating facilities. This hotel car - PRESIDENT - was equipped with cooking facilities and it operated on the Great Western Railway of Canada.

The first car designed exclusively for dining was built by Pullman in 1868. Named after a renowned restauranteur, DELMONICO, it operated between Chicago and St. Louis over the Alton Road.

Rivalling the most elegant hotel menus were the menus of these early dining cars. In the 1880's the festive dinners aboard the palace dining cars consisted of:

- a 10 course meal for a regular rate of 75-cents,
- a wine list containing 7 brands of champagne,
- Milwaukee lager beer for 15-cents a pint,
- cigarettes for 15-cents a bunch.

Frederick Henry Harvey brought "glistening silver, cut glass, and snowy linen," as well as well prepared meals to the old America West. He was often given credit for "civilizing the West."

After World War II, North Americans began their love affair with cars and the businessman found that he could cover a lot more territory in less time by taking the plane (King, 1976). The trains had lost their biggest customers - the personal traveller and the businessman.

Because of this turn of events the railroads were forced to cut back. No new equipment was ordered and the cars began to show their age. With the decline of passenger service, many aspects of food service were neglected. The available money and talent was devoted to maintaining the profitable end of the business - the freight trains.

For some time this situation prevailed, until the era of the uncluttered highway and accessible airport came to an end. It soon became evident that trains were sometimes more advantageous in terms of:

- speed
- comfort, and
- efficiency (with respect to energy use and congestion).

To take advantage of a growing passenger market, an extensive refurbishing of existing cars began, as well as purchase of new train coaches.

Coach Types

With Congress-appropriated funds, Amtrak persuaded the Administration to purchase new cars (King, 1976). The Amcafes, a food service coach, could provide food service for passengers throughout the train as well as carry up to 60 passengers in corridor service.

The Amclub cars, have a parlor section with room for 18 persons in a two-and-one seating arrangement. Included are 28 seats in the coach section and a food service bar for coach passengers. In addition, both the Amcafes and the Amclub cars have been provided with accommodation for the handicapped.

In addition, Amtrak began work in 1975 on a coach/dinette car. The dining section of the car has room for 32 and the coach section has room for 28.

The kind of equipment that Amtrak had set out to provide in the area of food services will hopefully enable the train to compete more successfully with airlines, buses, and cars.

In order to raise the standard of comfort in their trains Amtrak has delivered the second generation Amfleet II cars. Twenty-five lounge-cafe cars were put into operation in late 1981.

The coaches have 59 seats arranged in pairs. To enable more leg-room for passengers, as well as having folding tables, leg and foot rests, the winged seats were replaced by flat-back seats.

The lounge-cafe cars have bays of seats with tables at one end and a lounge at the other end. More food preparation is possible on the Amfleet II than was possible on early "Amdinettes." The galley includes refrigerators, coffee makers, a griddle, and microwave and holding ovens.

The new Amtrak double-deck Superliner coaches, introduced in service in 1979, have a dining car with a lower-deck galley and restaurant area upstairs.

The lounge-cafe cars are designed for entertainment and relaxation. A piano lounge and a snack bar are on the lower level. On the upper level there is a lounge with two observation areas at either end. Also available for use are two tape players, an FM radio and two video TV sets.

The lounge-car allows passengers to appreciate the view by having deeper windows than other train vehicles. In addition, there are windows that run the length of the roof on both sides of the car.

The most recent Canadian trainset is the LRC (Light Rail Coach). The Buffeteria LRC Coach provides food and beverage facilities in the centre of the car and can service adjacent coaches (Alcan Dofasco MLW, no date). The tables for two are located at the windows and the tables for four are along the centre line of the coach. This cafe setting with booth-style seating at one end is 85 feet (about 28 meters) in length.

The Bar-Lounge LRC Coach accomodates both premium and coach class seating arrangements. Galley-bar facilities are available. The bar is complete with stools and lounge area. The lounge section has contoured chairs and a wagon circulating for seated passenger refreshment service.

The Club-Galley LRC Coach is intended for premium-class seating arrangement, with either a two-plus-one or a two-plus-two layout. To ensure that the tray remains level when the seat in front is reclined, the refreshment tray in the club-galley is attached to the seat base.

Equipment Design

Rooms and their fitments should be matched to human requirements (Grandjean, 1979). Body starin can arise from holding the body in unnatural positions (bending the back, stooping to reach equipment) or moving heavy objects (lifting a heavy object, carrying a heavy piece of equipment). Static efforts can cause static muscular strain as well as deteriorate the intervertebral discs and increase the risk of back hazards (backache, sciatica, lumbago) and some rheumatic diseases (tendinoses, arthroses).

It is important to design areas with adequate space available for equipment and passage ways. As well, providing sufficient space in front of equipment or furniture that requires someone to stoop or kneel is important for efficiency as well as safety.

Studies have been done in the home environment to determine the influence that the surface of the kitchen has on the habit of taking meals in the kitchen. In order for the kitchen to be chosen as the eating place, it should be at least 10 square metres.

Social status was also found to influence the choice of eating place. The lower middle class takes meals in the kitchen nearly 3 times as often as the upper middle class.

Food Service

Tennyson (1976) recommends that meals should be provided on trips that are longer than 2 1/2 hours. Extensive survey work has been conducted by Amtrak to determine what "users" think (Graham, 1976). For the short distance passenger - under four hours travel time - "food" was not seen as an important factor in the choice of travel mode. In one survey, 67 percent of the passengers rated the importance of food service in the lowest categories as their "reason for train travel." Sandwiches, salads, soups, and soft drinks were desired by the majority who wanted food service. Full meals were identified by very few people. No food with only bar service was suggested by 10 percent.

But, "doing a survey" about eating is dumb methodology. Direct observation of riders - say between London and Toronto - will show how many but snacks.

For the mid-distance traveler - four to twelve hour - the preference is still for fast food service. A sit-down bar and food service facilities should be available for them to entertain friends prior to their taking the train. At the twelve-hour end of the continuum, first-class food service and a diner where full meal service is provided at the proper times is essential. For there to be any volume of traffic in the diners the average passenger seeks a price range that is relatively low for a complete dinner.

The category of passengers on long-distance trains - over twelve hours - is completely different from those found on the mid-distance or short distance trip. Long-distance train travellers are a pleasure-oriented group who take a train trip every one or two years. The reasons for taking the train range from vacation travel to visiting friends or relatives. There are few business travelers on long-distance trains. From the standpoint of these passengers the train trip is part of their vacation and it should provide every amenity to make it a pleasurable experience. The crucial feature then becomes the provision of full-scale, first-class meal service.

Long-distance rail companies ought to consider offering as comprehensive a service as possible (Streichardt, 1981), even though full catering service may be seen as a great financial burden.

A study published by British Rail identified that when catering was scrapped there was a 3.5% drop in revenue because of 2% fewer travellers. A more recent study conducted by Deutsche Bundesbahn produced similar results (cited by Streichardt, 1981).

A focus group methodology was used to explore ways in which consumers perceived long distance travel (Behavioural Team, 1979). It is important to note that "Food/Bar" was rated as one of the ten most frequently mentioned topics beyond cost and trip time in choosing whether or not to use the train. On the other hand, Metroliner users who were more accustomed to plane travel ranked "food/bar" lower in their list of concerns than did the other D.C. Amtrak users.

Journey time is the prime factor influencing the Bordeaux business passengers rather than special amenities such as full meal service (Perren, 1982). Travellers differ in their eating needs and provision must be made for these various passengers (Perren, 1978). The first class passenger on regular well-loaded French business trains takes breakfast and dinner. Whereas, for the second-class ticket holder - often families - meal service should be available at most times of the day, but - more usually - lunch.

The menu should accommodate each of the various groups. For the families, both the two course and the three course (including lunch) should be available.

The question posed at this point in time is whether catering should continue despite increasing costs and smaller profits (Streichardt, 1981). Although we have the two extremes from first-rate full service to the basic self-serve mobile refreshment stalls, the trend even at the full service seems to be towards precooked foods, limited menus and reduced service.

The next logical step is toward self-serve or on-the-spot "mini-service." This would enable lower staff number and the use of disposable cups and plates.

The journey from Paris to Bordeaux, by the southbound "Aquitaine," has had changes in the train's catering cover (Perren, 1982). The bar car was removed, the full restaurant service is confined to the restaurant car which consists of 42 seats. In addition, meals are no longer served to passengers in their reserved seats. Instead of the five courses previously offered, the food is now a simple a la carte menu. Meals are put on the plate in the kitchen, allowing the discontinuation of "silver service." The SNCF has made these changes to reduce the high staffing costs.

The "Gril Express" self-service restaurant car of French Railways Trans-Europe Express (TEE) is restricted to 160 km/h. Since the "Corail" bar and meal service rides well at 200 km/h it has made more sense to use Corail stock and to provide catering at first-class seats. With journey time being the passengers main criterion, the "Corail 200" is a highly marketable service of the TEE.

Smoking

There was no mention made of smoking and its implication in the literature relevant to lounge, snack bars, and restaurants. This suggests that there is clearly a need to establish criteria as to place and times during which smoking is acceptable. Researchers can start by addressing the problems faced by non-smokers who must tolerate smoke while they are dining.

The Poor Public Image

The quality of rail catering has been under question for many years. A poor public image has been supported in some cases with reports of unhygienic kitchen cars and dishonest train-catering staff (Perren, 1978).

A major source of public dissatisfaction is the buffet car service. One of the reasons for this dissatisfaction is the fact that there is no equipment (i.e., microwave ovens) in the locomotive-hauled (Mk1) buffets which can be used to provide hot food speedily.

The trend in European railways is to restrict full meal service to first-class only whereas rail travel in Britain has decided to keep full meals with the traditional "silver service."

Perren (1978) notes that in analyzing letters of complaint for one month to Travellers-Fare, an on-train catering service company in Great Britain, the following aspects were identified:

* Unreliability of advertised service	28%
* Staff behaviour	20%
* Prices	16%
* Poor Food	12%
* General decline of service	10%
* Other miscellaneous topics	14%

One of the basic reasons for the poor image of train catering is the difficulty encountered in putting the food on the train.

British Rail feel that the problem is the age and condition of Mk1 locomotive-hauled catering vehicles. The Mk1 were built between 1958 and 1962 and are therefore up to 25 years old. Even though many have been refurbished, they are a steam-era design unsuited to today's demands. In particular they have a low level of operational availability; they don't satisfy the amenity standards, and in most cases the kitchen equipment is obsolete.

Perren (1978) states that British Rail's failure to introduce the Mk2 and Mk3 service catering cars is one of the reasons for the difficulties faced by train catering today. Whereas passenger-carriage design and catering-equipment technology have advanced, this area has remained outdated.

There are three factors which have been identified as problems for train catering:

* Vehicle availability - To keep the vehicles from becoming obsolete, they are often refurbished. Unfortunately this means that the limited number of vehicles are even more scarce.

* Experienced staff and staff morale - It is difficult to find staff who are capable not only of serving well, but of serving on a moving vehicle. Some of the factors influencing staff morale are length of working day, complaints and frustrations of angry travellers who have just had their trip cancelled, and problems in the various maintenance tasks required for safe and hygienic operations.

* Level of deficit - This factor alone influences the price of food and drink, the number of daily services justified, and the future investments made by the rail company.

The information gathered by Perren (1978) is particularly relevant to British Rail and Travellers-Fare that runs the largest train-catering operation in the world. They are Britain's largest and only truly national catering organization.

The primary features in passenger requirements are:

* reliability in the provision of the facilities advertised;
* good food and service;
* an efficient, cheerful staff;
* variety of choice; and
* value for money.

Although the focus group methodology study conducted by Behavioural Team (1979) was limited in sample size, it does enable a discussion of what services should be improved. The comments made about food service were negative. Both "quality of food" and "lack of variety in the menu" are noted as particularly objectionable for regular riders and those passengers on long trips.

In addition, respondents felt particularly displeased with:

* the wait for a diner car
* the decreased service resulting from cutbacks (i.e., crumbs on the table)

Snack cars face problems as well. Understaffing sometimes results in a hostile attitude on the part of the server. This attitude is particularly offensive to the passenger when they are also faced with running out of supies, long lines and mediocre food.

In order to improve food services it is important to start by planning adequate staffing and sufficient provisions.

Improving Passenger Communications

With the deepening energy crisis, railways are beginning to be freed from competition with airlines and the car (Streichardt, 1981). Thought should be given to:

- a) climbing costs,
- b) the understandable demands of employees for better working conditions, and
- c) the many and varied wishes of travellers.

In addition, it is important to improve passenger communication (Perren, 1978). One way of achieving this is by providing more detailed information, especially for optional second class passengers who do not use the train as frequently. Some examples of such information are:

* available menus,
* prices,
* times that meals are served, and
* how to reserve restaurant car seats.

The contribution that on-train catering facilities make to the appeal on inter-city travel was examined in a full market survey conducted by James Spillius Research Limited (Perren, 1978). Among the main points summarized from the report were:

1) providing reliable, frequent and well-stocked trolley service

2) improvement in the reliability of basic catering products

3) having a constant supply of hot drinks and to a lesser extent cold drinks and alcohol

4) making sure it was possible to obtain sandwiches and snacks

5) re-designing the buffet car

6) if restaurant services are reduced, better quality of buffet food - good pub food, more hot snacks, and variety - is needed

7) improvement in buffet fare (since the buffet fare is not included in the price of the ticket as would be the case with airplanes)

8) the retention of breakfast

9) offering de-luxe restaurant car meals on few key routes

10) providing enough information so that the traveller is aware of what is available at what price

11) reducing the price of some basic items

CONCLUSIONS

The human factors concerns involved with the service of food and drinks range all the way from the floorplan to the legibility of the menu. Although the age of elegant gourmet dining on the train may be gone, there are still standards that can help ensure an enjoyable meal or pleasant time having a drink with friends.

Recent studies of passenger attitudes reveal that these restaurant, snack and bar/lounge facilities are quite important to long distance train travellers. Careful analysis of these attitudes and complaints concerning food and services can indicate areas for improvement.

2.7 General Psychological Considerations

In recent years, transportation studies have employed concepts and techniques drawn from the behavioural sciences. In part, this trend represents recognition by transportation specialists of the insights to be gained from studying consumer behaviour.

Planners are no longer thinking in terms of projecting future travel demand patterns and then developing new facilities to meet the forecasted demand. Instead, they are considering how to encourage travel behaviour which contributes to the success of policies upgrading travel systems, urban development and the environment. Efforts are therefore being made to tailor the attributes of transportation systems more closely to consumer preferences, while monitoring and evaluation programs are being established to measure the effectiveness of particular managerial strategies in the transportation marketplace. Research techniques are being used to determine not merely the size of the travel market, but also ways in which it is segmented; to evaluate public attitudes towards both proposed and existing facilities; and to develop a better understanding of the factors underlying traveler decision-making and how consumers' decisions may be influenced.

Two basic approaches are available to transportation planners and managers who seek to change modal choice behaviour among existing alternatives. One approach is to change the actual characteristics of one or more competing modes, thereby altering the relative attractiveness of each to the user. The second is to use communications to change the perceived characteristics of the modes in question.

With both approaches, a consideration of the relationship between attitudes and subsequent behaviour is essential. Charles River Associates (1978) explored several noteworthy multi-attribute and hierarchical models that are useful in conceptualizing the relationship between consumer perceptions, attitudes, and behaviour. Although there are subtle differences in orientation between the various models, there is agreement with the following concept: feelings about engaging in a particular behaviour (e.g. mode of travel) are a function of one's beliefs that performing a certain behaviour leads to a certain outcome. It is also a function of the person's evaluation of the desirability of that outcome, and the person's perception as to how other people (e.g. peers) in question feel about the appropriateness of engaging in the behaviour.

2.7.1 Regulation of Human Contact

OVERVIEW

According to Greenberg et al. (1980), personal space is a mechanism used to regulate interpersonal interaction and to achieve a desired level of privacy. Thus, the invasion of one's personal space zone is likened to privacy invasion, or the thwarting of desired privacy goals.

REVIEW OF THE RESEARCH

There is sufficient evidence to indicate that "externally" controlled individuals have larger personal space zones than "internally" controlled individuals because they feel they could not control a person close to them to the same degree. In sum, comfort, privacy and control all appear to be interrelated with respect to interpersonal distance. Researchers have employed the comfort trait approach in assessing interpersonal distance. The interpersonal distance traits of comfort, control, and privacy have been shown to possess convergent validity.

A propos to the question of privacy is the issue of crime. An overall approach to the question of crime on transport systems has three general components:

1. The establishment of the nature and extent of crime on the system and its relation to overall crime statistics.
2. The public's perception of security and the extent to which it will affect ridership.
3. The deployment of effective means not only to reduce crime but also to increase the public's perception of security, and to do both in a cost-effective manner.

The results of a study by Shellow et al. (1974) indicate that with heightened national awareness of crime, particularly stranger-to-stranger crime, the public is likely to be highly sensitized. Anticipation itself quite likely adds to the impact of each publicized crime, especially if crime occurs in space where people feel trapped.

This is the paradox that is so central to any consideration of transport security. It is not the reality of crime on the system that makes the difference, but how it is differentially perceived. Furthermore, the general public expresses considerable concern over crime on the system even though this concern appears to be out of reasonable proportion to the occurrence of criminal events. There is mounting evidence that citizens feel secure when there is the conviction that government is responsive to their needs.

On the basis of their study of existing and perceived crime on the rapid transit system of a major metropolitan area, Shellow et al. (1974) propose an integrated alert system, which is a combination of an alarm, telephone, and closed-circuit television monitoring (CCTV) system. This coordinated system, which they term the teleview alert (TVA) system, holds promise in that it reduces false alarms, provides critical surveillance information, and allows the public to quickly notify the authorities of the problem.

The authors note that although not intended to represent transit systems in all cities (and certainly not all railroad settings), their findings suggest conclusions that are sufficiently basic to transit development programs. As such, their findings should be given serious consideration in the improvement of existing rail systems or in the design of new ones. They state that the total cost for such a security system appears relatively small when it is compared to the construction and operating expenses of a rapid transit system. This cost (which the authors do not specify) supposedly compares favorably to the heavy costs incurred when manned patrol is relied on exclusively.

Thrasher and Schnell (1974) describe the findings of six studies in five cities on the question of whether fear of transit crime and vandalism affects a person's decisions to use urban transit systems. Despite areas of disagreement, the following tentative conclusions can be drawn from the six studies:

1. Transit crime can exert strong influence on passenger decisions concerning use of urban mass transit, but there are many variations depending on the volume of crime or vandalism in the area served by a particular route, the transportation alternatives available to the passengers, and the hours at which they must ride.
2. In general, and subject to deviations according to local conditions, transit crime and vandalism are more likely to influence passengers riding on rapid transit than on buses.
3. It is difficult to establish that a given change in ridership is caused by a single factor such as crime or vandalism. In any situation there may be a combination of factors that influence ridership.

Controlling crime and vandalism involves various approaches: resistant materials, deterrence, protection, surveillance, dissuasion, community involvement, cooperation with educational authorities, coordination with institutions, and analysis of passenger attitudes. The general opinion among those working to overcome crime and vandalism is that none of these approaches can be successful on its own and that the most effective means of combating crime and vandalism is the sustained use of a combination of all approaches.

A report by Thrasher and Schnell (1974) shows the following gaps in knowledge that require new or continued research:

1. The collecting of statistics on crime and vandalism should be continued on an annual basis, and the data should be systematized and standardized to facilitate comparisons and study of trends.
2. Extrapolations of the number of criminal incidents and the totals of vandalism costs on a national basis should be refined and extended.
3. Data on experience with types of damage-resisting materials should be accumulated.

CONCLUSIONS

More work needs to be done on the question of public attitudes toward transport crime and vandalism. At the present time, there is a dearth of research on the nature and extent of crime and vandalism on long distance train journeys and the influence this has on ridership.

2.7.2 Relation Between Perceived Cost of Furnishings and "Comfort"

OVERVIEW

Passenger comfort is clearly a key variable in research on user acceptance of transportation systems (Richards et al., 1978). On the one hand, it is the most direct psychological correlate of ride quality; and on the other, it is related to a passenger's satisfaction with a mode of travel.

REVIEW OF THE RESEARCH

Comfort is a state of feeling - an affective reaction. As such, it depends upon both a situation or environment and a person experiencing a situation. The subjective nature of comfort reactions requires that we ask people to report to us how comfortable they are. We cannot know directly by observation.

An inherent feature of human reactions or judgments of this kind is the variability that results. If a number of people tell us how they feel about the same situation, their responses will differ from each other. Not all people react to the same situation in the same way. Given that such variability exits in a particular context, we can ask whether it is in any way systematic. Do characteristics of the respondents as persons (individuals) relate systematically to their reactions in the situation?

Potentially relevant individual difference variables include:

(1) attitudes, beliefs, expectations, fears, moods, and anxiety - psychological factors,
(2) tendency toward motion sickness, and general health - physiological factors, and
(3) age, sex, socioeconomic status, and demographic factors.

Although no evidence is provided to support his claim, Hafter (1972) states that for most members of the travelling public, mention of the word "comfort" tends to be equated primarily with visions of armchairs and soft carpeting. The rising standards of comfort now taken for granted in the home have made travellers more critical of their surroundings during travel. The widespread ownership of motor vehicles has also given members of the public greater critical appreciation of standards of seating, heating and ventilation, and they are unwilling to accept lower standards in public transport than they can obtain in their own vehicles. If people are to give up the door-to-door convenience of private transport they expect greater comfort and speed in public transport by way of compensation.

CONCLUSIONS

The research discussed above supports the view that passenger comfort is a key variable in determining mode of travel.

2.7.3 Relation Between Perceived Cleanliness and "Comfort"

The literature on long distance train travel pays no attention to the relation between perceived cleanliness and "comfort." The relationship is most likely a direct one, considering the general high levels of hygienic standards that most North Americans are accustomed to.

In general, the manner in which people behave in their environment is closely linked with feelings evoked by that environment. Experiencing feelings is a complex apprehending and appraising process which is influenced by an individual's environmental dispositions and sensitivities. Individuals assign meaning to aspects of their environment through feelings that the environment evokes. Thus, feelings are mediators between encounters with an environment and subsequent behaviour in that environment.

Because feelings impact strongly on evaluations and subsequent behaviour, it is important that surveys be adopted with questions that mainly address persons' feelings toward specific aspects of that environment. This particularly applies in instances where changes in design criteria would affect passengers' perceptions.

2.7.4 Perceived and Actual Safety

OVERVIEW

According to Gregg (1983), the most sensible measure of the human risk associated with a given transport activity - and one which is almost universally adopted - is the number of casualties per passenger-mile or per ton-mile. On this test, rail is much safer than road.

REVIEW OF THE RESEARCH

In Britain, the internal cost of car travel is some four times greater than that of rail travel. It is moving accidents - usually involving some degree of responsibility on the part of the passenger himself - which account for the major part of the fatality rate for railway passengers.

Movement accidents to rail passengers can be reduced by establishing precautionary measures during boarding and alighting. Gregg (1983) makes the unsupported claim that "movement accidents to railway staff have already fallen markedly in recent years." He asserts that movement accidents can be reduced still further "as working methods improve and a yet higher safety-consciousness is raised." Unfortunately, he does not discuss the working methods he refers to.

In 1970, the Railway Transport Committee (RTC) of the Canada Transport Commission

(CTC), the body responsible for the regulation of railways, became extremely concerned with the hazards of railway operations. Their concern was triggered by three accidents which occurred within a span of only nine days in the summer of 1970. The result of RTC's (CTC) inquiry into the safety of railway operations, launched in 1970, were published in 1973. The RTC concluded that "train wrecks had reached such proportions as to require action more drastic than its prevailing safety program entailed," and that "there is still a long way to go before acceptable standards of operation and maintenance of railway trains are reached in Canada."

Recommendations were made on some 16 topics which covered signal systems and traffic control, tracks and roadbed, rolling stock, and accident investigations. The RTC warned that "it will be necessary to require the railways ... to reduce the maximum net weight of car loads to 70 or 80 tons per car ... and ... to reduce the speed of trains wherever the existing speeds are contributing to excessive stresses." In short, the RTC's massive inquiry established beyond doubt the unsatisfactory safety of railway operations in Canada in the early 1970s.

Following the derailment of a CP train in Mississauga on November 10, 1979, which resulted in propane fires and explosions, spillage of deadly chlorine and evacuation of some 230,000 people, the safety of railway operations in Canada was once again widely questioned. According to Lukasiewicz (1980), contrary to the statements made by CN and CP spokespersons after the Mississauga accident, the safety record of Canadian railways continues to be highly unsatisfactory. The truth of this statement is borne out in a recent VIA Rail crash in March 1983 which, according to an official of the Canada Transport Commission, could have been prevented if a maintenance crew working in the area had followed proper procedures.

Lukasiewicz (1980) states that two criteria should be used in assessing the safety of transportation.

The relative hazard, of interest to the operators of transportation, passengers and shippers of goods, is usually measured in terms of accidents (their number, or cost, or number of casualties, etc.) per unit transportation output, i.e. per ton-mile or per passenger-mile. On this basis, the safety of transportation modes can be compared (e.g. aircraft versus automobile) and the variation of safety of each mode over time can be determined.

The absolute hazard, of interest to the general public, is expressed as the number of accidents (or casualties, fires, collisions, derailments, crashes, ect.) per year, regardless of traffic volume.
Absolute Hazard = (Relative Hazard) X (Traffic Volume).

The absolute hazard is an important measure of the indirect impact of accidents on environment (including the general public), and should be the criterion for determining the acceptable level of relative hazard.

The poor safety record of Canadian railways is, in Lukasiewicz's view, mainly due to obsolescence of technology and operating practices. This can be well appreciated through comparison with the progress achieved by airlines - a transportation mode developed by modern, dynamic industry and managed by modern enterprises (Lukasiewicz, 1980).

The obsolescence and corresponding poor safety record of Canadian railways are to a large extent the result of financial constraints under which railways operate. To meet the competition under conditions of inequitable subsidization, railways have opted for short term profit at the expense of modernization and maintenance.

According to Lukasiewicz (1980), modernization of technology and operating practices is the key to the improvement of railway safety in Canada. When technology is deficient, bureaucratic and legalistic measures cannot be effective or economically feasible.

Modernization can be accelerated through (i) legislation of modern performance standards for tracks (including road crossings), traffic controls and vehicles, and (ii) modification of financing of railways to bring it in line with financing of the other modes.

While many materials are being considered for transport usage, very little is known about their toxicity (Houston, 1976). Furthermore, no standard exists for determining their relative toxicity. Among the problems researchers are facing is that each toxicant given off by burning plastic has a different level at which it is lethal. Actual death may be due to a trace of an unidentified toxicant even if large amounts of less toxic substances are found.

The prototype public transportation seat developed by British Railways eliminates polyurethane foam cushioning, identified as a major flammability problem. The seat, which works on the principle of net suspension, uses a flame retardent polyester as the seating material, said to offer comfort, light weight, and ease of cleaning.

The R-44 subway cars were first unveiled on July 10, 1969 by the New York City Transit Authority. Since then, the City Council Mass Transit Committee (1975) has fully documented errors in concepts, design, construction, testing, and maintenance.

Focusing on the technical faults in the design of these vehicles, the authors make specific recommendations about the criteria to be used when manufacturing transit vehicles.

In January 1982, the first of 210 new sleeping cars were put in service between London and Aberdeen on British Rail's East Coast main line. Interior design of the sleepers had to be modified considerably after the sleeping car fire at Taunton in 1978 in which 12 passengers died. Graviner smoke detectors are located in every part of the car, linked to a complex electronic unit that gives different levels of warning according to the condition detected. It should be noted that fire precautions added so much to the cost that the order had to be reduced from 236 to 210 cars, and their entry into service was delayed for several months for the same reason.

CONCLUSIONS

It is evident from mistakes made in the past that proper planning of rail safety systems in advance of their construction saves costs - both human and financial.

2.7.5 Phobias, Fears

Though much literature exists on the etiology and characteristics of phobias in general, no attention has yet been paid to examining what impact they have on influencing travel behaviour. For example, there is no data on the prevalence of train phobia in Canada, nor the extent to which it affects passenger ridership.

A few years ago, Behavioural Team studied acrophobia as it relates to elevated section rail travel. It was concluded that higher window sills would reduce fears. For those experiencing claustophobia, it was felt that the design of emergency "values" needed special care. Specifically, a balance was needed between conspicuousness and restraint - and "screaming" reds should be avoided!

It is clear from the paucity of research in this area that further information needs to be gathered to determine consumer needs.

2.7.6 Stress Reduction

OVERVIEW

The concept of stress has become well incorporated into the everyday parlance of twentieth-century culture. Such expressions as "I'm under a lot of pressure," "I'm swamped," "There's a lot of tension in my life," "I can't cope with it," "I'm feeling the strain," "I'm undergoing constant anxiety," and "Things are happening too fast," are frequently used to indicate the experience of stress. Sometimes the focus of the expression is on an external force impinging on the person; at other times the reference is to the person's own internal response to that force - or to an interaction between external threat and internal response.

REVIEW OF THE RESEARCH

Some psychologists consider it necessary to include curiosity as one of the fundamental human motives. Exponents of this belief regard the nervous system as an active rather than merely passive recipient of stimulaton.

Boredom - or the complete absence of personal tension - is a subjective state characterized by unpleasant feelings that arise from a lack of curiosity. In such a state, people are uninterested in the social environment about them. In psychological terms, boredom is the extinction of an orienting reflex or of observing responses.

There are normally four factors that play a role in boredom. These are: constraint, unpleasantness, low arousal, and repetitiveness of a task. One of the potential negative consequences of a state of lowered arousal could be a lack of alertness, which may predispose one to accidents.

Although "extroverts" are apt to become bored more quickly than "introverts" on monotonous tasks, further research is needed to explore individual variability in response to boredom.

Though considerable research effort has gone into the problems of short distance or commuter travel, there is comparably little research directed to the problem of long distance travelers. As a result of pilot studies, Tainsh (1975) discovered that the incidence of at least 14 symptons could be associated with the frequency of making long distance journeys over a period of two years. These were anxiety, restlessness, abdominal pains, indigestion, fatigue, headaches, muscular stiffness, eyestrain, vomiting, dizziness, depression, and backache.

A larger study involved 165 workers from over 60 industrial organizations in the West Midlands. They volunteered to participate (Tainsh, 1975) and the following results emerged:

- The frequency of making long distance journeys is significantly related to the strength or frequency of seven symptoms (restlessness, fatigue, headache, backache, eyestrain, dizziness and indigestion) for train travel but only one for car travel (fatigue). This suggests that the frequency of making these journeys is more important in determining symptoms following train travel than car travel.
- People travelling once a fortnight by train are unlikely to report any symptoms but when journeys are made once a week or more there is an increase in the probability of experiencing a symptom.
- Personality factors (as measured by Eysenck's neuroticism scale) are more important in determining symptoms following car travel than train travel. This implies that frequent train travel is more likely to be unsettling to a broader group of people than is frequent car travel. It should be noted that in this study no mention is made of the design features of the train(s) which might have affected persons' reactions to the long journeys.
- Socio-economic status is relatively unimportant in influencing the reporting of symptoms following car or train travelling. This result must be treated with skepticism as the author does not provide a breakdown by percentage of each group of people classified according to this criteria.

It must be stressed that these results cannot by themselves lead to the firm conclusion that there are long-term health effects as a result of car and train travel. There are clearly influences of memory and recall which may have a bearing on the data which was gathered. In the above study, an assessment of the incidence of symptoms was made of journeys by car and train over a two year period.

CONCLUSIONS

Stress, whether it manifest itself in boredom or in debilitating physical symptomatology, is an issue that clearly impacts on travelers making long distance train journeys. Personality variables interact with environmental variables in determining the nature of the stress reaction.

2.7.7 Entertainment, Festivities

French passenger rail (SNCF) has diversified the services provided for passengers travelling in parties because of the development of this type of traffic. There are four types of special coach presently operating. These are: conference-seminar coaches, visual coach, cinema coach, disco-bar coaches.

There are no indications in the literature on rail passenger service in North America that authorities are paying much attention to consumer demand in terms of the special services mentioned above. These services, potentially major determinants of passenger ridership and passenger satisfaction, may well be worth offering. Consumer marketing studies and cost-efficiency studies in this area are overdue.

It should be noted that Behavioural Team's Amtrak studies uncovered great pools of nostalgia for train travel. Many people had fond recollections of the social atmosphere in club cars and the enforced meetings in dining cars.

2.7.8 Special Travel Groups

OVERVIEW

Commercial airlines and passenger ships have benefitted monetarily by attending to the needs of special travel groups. The lack of attention to special travel groups by passenger rail, as indicated by the deficient information available in the literature, would suggest that this is a neglected topic.

REVIEW OF THE RESEARCH

One area worthy of future study is that of senior citizens. In Canada, only a few long-range planning studies address the issue of seniors' transportation; in fact, Canadian governments are only recently beginning to realize that seniors will comprise a rapidly growing proportion of society (Wolfe & Miller, 1982).

Expectations concerning tomorrow's elderly include:

1) Seniors will be healthier as a group. This assumption is based on increasing survival rates.
2) Seniors will be more independent in their living arrangements. Today's independent women can be expected to be continue their independence as seniors.
3) Seniors will be more educated and have broader interests. This has implications for the encouragement of long train journeys (eg. heritage journeys) which might appeal to a more educated public.

The above discussion on senior citizens is but one illustration of the many opportunities passenger rail can provide for special travel groups.

There is a growing need for the transportation industry to develop meaningful policies and procedures for transporting unaccompanied children (McAllester, 1982). Changing family lifestyles, typified by the higher incidence of divorce, have made travel by unaccompanied children a regular occurrence.

The increase in the number of split and multiple families over the last decade has created a need for children to travel alone between cities to visit or be with alternate family segments (McAllester, 1982). Many of these children with divorced or separated parents must regularly or occasionally travel between parents. Often, such travel is in the summer or holiday periods.

As joint-custody decisions by courts grow in popularity, travel between parents becomes more frequent. When divorced parents live in separate communities, travel arrangements become even more difficult and costly. Time away from work may also be a restricting factor that could prevent a parent from driving a child or accompanying him/her on public transportation to a distant city. Under these conditions, providing a safe means for a child to travel alone becomes important to the parents. They must be assured that convenient, economical, and most important, secure arrangements for unaccompanied travel are made available.

The relationship between the maturity of a child and the amount of supervision required for unaccompanied travel is critical in developing rules and procedures for unaccompanied travel. Jean Piaget's studies of cognitive development in children offer some insight into how children of different ages respond to their environment.

Piaget was a psychologist who discovered that cognitive development proceeded through several stages and that children reach these stages at consistently predictable ages. In the "preoperational" stage, between ages two and seven, children have limited perceptions of the surrounding world. Such children cannot understand the points of view of others. At this stage, children focus primarily on one feature of a situation, and they usually perceive the world as static and unchanging. These characteristics indicate that children between ages two and seven are too young to travel alone and encounter strange, new situations without considerable supervision from an attendant.

In the "concrete operations" stage, between ages seven and eleven, children develop the ability to classify objects and have the capacity for logical thought. Children at this stage are capable of focusing attention on more than one aspect of a situation. These children would have a greater awareness of the surrounding world and would need only a moderate degree of assistance for unaccompanied travel.

In the "formal operations" stage, between ages eleven and fifteen, children have a full awareness of the physical environment and develop the capacity for abstract thought. At this stage, children are able to derive a number of solutions to any given problem. Children at this stage should be fully capable of understanding and constructively responding to a new environment.

CONCLUSIONS

Changes in family lifestyle might encourage more intercity travel by unaccompanied children than ever before. In order to deal effectively with this potential new influx of children, especially at ages unable to fully adapt to new conditions, the rail industry should develop travel policies to ensure that unaccompanied children are adequately protected and supervised. Policy decisions for unaccompanied travel should reasonably balance minimum age requirements, supervision, fares, trip itinerary restrictions, and station facility conditions. All of these considerations can directly result in better quality of intercity rail transportation available for unaccompanied children.

2.7.9 Travelling With Pets, Valuable Livestock, Etc.

Pets, for many people, are like members of the family. The idea of travelling without them is inconceivable to some owners. It is surprising that little research has been conducted to determine the difficulties passengers have in travelling with their pets. Boarding, handling and treatment of pets by staff are some concerns that could be addressed to ensure that a high quality of service is being maintained.

3. Interactions With Rail Personnel

3.1 Identifying Help, Information, or Authority Figures

OVERVIEW

This section deals with an article on uniforms bought by hotels or restaurants, and by extension, transportation companies, for their staff. The function of the uniform, what kinds are popular, and what are the benefits and disadvantages of different aspects of the uniform are discussed.

REVIEW OF THE RESEARCH

When a restaurant, hotel or passenger transportation operator buys uniforms for his staff, he is also buying a certain image for his operation. In today's market it is important that the image be a positive one. Therefore appearance and style of the uniforms are top priorities in choosing them. Every operator wants to ensure that his staff's uniforms reflect the uniqueness of the establishment or operation.

The uniform must be stylish but also live up to performance standards. The uniform should be attractive as well as practical and comfortable. A badly fitted or badly designed uniform destroys the establishment's image, causes employee discomfort, and negatively affects his/her performance.

The buyer who is responsible for purchasing a large order of uniforms is concerned with durability, competitive pricing, and finding a company that can provide an adequate supply and good service.

There has been a recent trend toward simple and casual uniforms. Smaller operations are even encouraging their employees to wear their own clothing - i.e., black trousers or skirt and white shirt or blouse. Regarding colour, almost anything is used. In most instances, however, it is best to stick to one colour, since a combination of colours can result in laundering problems.

The most popular fabric is a blend of 80% polyester to 20% cotton. These permanent press fabrics are popular due to their long life span. Choosing the right fabric is important for appearance and for minimizing laundering costs. For this reason uniforms should be washable since they need to stand up to frequent laundering. Most manufacturers believe that a good uniform will last nine months to two years.

For employees who must move around a lot, lift things, or stretch, ample stretch room is needed under the arms, across the back, and around the chest and waist. Pockets are stylish and functional and are recommended for waitresses and waiters and others who must carry a notebook and pen.

CONCLUSIONS

The uniforms worn by train staff are an important aspect of the image they portray on behalf of the railway. Their uniforms should be attractive yet practical and comfortable. A badly fitted or badly laundered uniform detracts from the operation's image. It is best if the uniform be one colour, to minimize laundering problems. The most preferred fabric is 80% polyester and 20% cotton due to the long life span of permapress. The uniforms should be washable since they need to stand up to frequent laundering. A good uniform will last up to two years.

3.2 Training and Demeanor of Staff

OVERVIEW

This section considers the effect of noise on performance. Miscellaneous articles on work seating and computerized railway sales service are also reviewed as well as an article on the New Driver of the future.

REVIEW OF THE RESEARCH

In three experiments on performance of an addition task, Harris (1976) found no adverse effects of intermittent noise (105 dBA). This suggests that high intensity sound, even when unpredictable, does not have adverse effects on the performance of simple menial tasks. This contradicts other research that unpredictable noise can adversely effect human performance.

However, a mixed sound stimulus produced statistically signficant poorer proofreading performance than a control condition or a random intermittent noise condition. This finding is directly opposite to earlier studies where the random intermittent noise condition produced the greatest effects.

Harris (1976) concludes that more research is needed before the relative importance of stimulation intensity and unpredictability of stimulation can be evaluated.

In a paper on noise and driver performance, Williams and Jones (1980) state that noise can mask auditory cues arising from the horn and engine. In any one vehicle the degree of masking will depend on the relative intensities and frequencies of the noise present. Conversation may also suffer from the presence of noise. Speech has an acoustic pattern varying within a range of 100 to 8000 Hz., so any noise within that range may cause masking.

When task demands are low, both loud and moderate, variable or intermittent noise helps monitoring efficiency. When the task demands are high, noise may impair monitoring performance as in driving.

Williams and Jones cite research that on a digit detection task, unvarying noise at levels as low as 85 dB(c) results in a more cautious mode of responding. Other research shows that both intermittent and unvarying noise at 95 dB(c) significantly increased the number of responses with latencies over 1.5 seconds. Also, 70dB and 90dB variable noise increased tracking error on a tracking task.

In conclusion, these findings suggest that loud noise may mask auditory cues essential for good driving performance. Also, noise may mask speech which could lead to inattention while driving.

Second, loud and moderate noise may impair monitoring, motor and multi-component skilled performance. Also, loud unvarying noise may cause the driver to respond inappropriately to signals, make risky decisions, and to focus attention on a limited number of task components, while both loud and moderate levels of unvarying noise may impair motor performance.

These findings should apply equally well to train drivers, since driving a train is a high skill job affected by noise.

Effective work on the part of rail personnel is determined partly by comfortable work conditions, including seating. Fitzgerald (1977) described a work seat designed for ship's sonar-operators. However, it should be equally suitable for operators manning a variety of visual display panels, including train operators. The main features of the seat are:

1. a front and back horizontal adjustment facility of the seat on a fixed infrastructure,
2. forward and downward seat tilt facility to allow close screen scrutiny,
3. energy-absorbing foam in the seat's upholstery for vertical and lateral acceleration damping,
4. seatbase contouring for comfort during long-term sitting.

The dimensions of the chair are 45 cm wide X 42 cm long (deep) X 36 cm high. The wood is 2 cm thick. The backrest, at an angle of 98 degrees from the seat surface, is 37 cm high. Armrests extend 22 cm above the seat upholstery. The seat can be permanently fixed to the deck. A lever allows the seat occupant to position the seat in the desired position. An occupant watching sonar display console screens will use the seat in the 5 degree rearward tilt position, forward and downward. Such a seat might readily be used by train control panel operators.

A report on automated equipment for the SNCF by Bibily (1982) pointed out that the SNCF is trying to establish better communications with its customers through sales activities. This means that a specific training program is needed, with properly trained sales staff.

When a customer arrives at a sales counter, he expects to be informed about available services and to be able to buy tickets, make reservations, etc. Therefore, sales staff need a machine which facilitates their physical work. During the late 1970's the SNCF drew up specifications for a group of machines called Greta/Mabel (Groupe d'Etude d'un Terminal d'Avenir/Machine a Billets Electronique). By 1982, 700 machines had been delivered and installed at 300 stations. For every operation - sales, aftersales, or management - the operating mode displays all relevant information on a VDU screen. These machines can do every transaction required by a customer, including the issuing of tickets.

In a theoretical paper, Michon (1980) argues that the "New (automobile) Driver" will be more emancipated and more educated, more tolerant yet more egocentric, will display more aggression and less consideration in situations that offer opportunites for affect. The New Driver can be expected to be less willing to accept authority, to be procedure oriented, independent from environmental (especially organizational) factors, and more inclined to emotional responses (acting out). These predictions may hold for non-drivers as well.

The ergonomic implications of the above are as follows:

1. Instruction - teaching directed at the cognitive representation of skills may take precedence over the functional control - systems orientation that prevailed earlier.
2. Recuperative Maneuvers - this should get more emphasis as part of instruction and training.
3. Display of Information - strategies for enhancing cues which determine perceived risk are required.

While the New Driver of this article is meant to refer to car drivers, by extension it can refer also to train passengers or drivers. Since the motions of the train - and, in extreme cases, the occurrence of accidents - impacts on rider satisfaction and levels of ridership, some care is needed in identifying and training locomotive engineers. Their behaviour must be in keeping with VIA Rail passenger policy as well as ordinary safety demands.

CONCLUSIONS

The results of studies on the effects of noise on performance are mixed. Some studies show a decrement in performance and others do not. More research is needed. One study showed that when task demands are low, noise helps monitoring performance. When task demands are high, noise may impair monitoring performance, as in driving. Moreover, noise may mask auditory clues, including conversation, essential for good train driving.

3.3 Emergency Management

OVERVIEW

This section will consider two articles, one on risk and public safety and the other on emergency management in railways. Finally, an article on railroad clocks will be reviewed.

REVIEW OF THE RESEARCH

According to Siddall (1981), safety is the "degree to which (a) temporary ill health or injury, (b) chronic or permanent ill health or injury, or (c) death are controlled, avoided, prevented, made less frequent or less probable in a group of people (Sidall, 1981). Risk is "the frequency (in the past) or the probability (in the future) of death (or other hurt) per unit number of people per unit time, e.g., per million people per calendar year" (Siddall, 1981). Risk is a statistical concept.

Siddall (1981) reports that Canadian railways in 1953 produced $7.1 million product per human life lost (at 2.9 cents per passenger mile, 1.5 cents per ton mile).

Safety and risk are concepts which relate closely to management of railway emergencies such as collisions and derailments, which often cause loss of life.

According to Hay (1982) train derailments and collisions are usually due to human failure. Two immediate necessities in these situations are rescue and aid to victims and reopening the line of traffic. Special protection and investigation are required where hazardous substances are involved. Following this, an investigation to determine cause and planning to avoid future occurrences is conducted.

Weather hazards can be a large problem for railways. Drifted snow can make track impassable. Snow and ice on the rails can cause derailments. Snow and ice on driveways and platforms slow the movement of freight-handling vehicles, cause inconvenience and shipping hazards for customers and employees, and even switch stoppages. Preparation for the first snow includes buying snow brooms, shovels, salt and hydrocarbon (snow-burning) oil. Snowplows and other snow removal equipment must be checked and repaired. Sources of personnel must be arranged and trucking companies and contractors must be called on to provide transportation and other equipment for snow removal and haulage. Sometimes temporary snow fences are used to cause the snow to drift away from the road.

Problems caused by ice storms are loss of communication and signal lines, and tracks blocked by fallen trees, poles, and wires. The worst situation is when ice-laden wires and trees start swinging due to heavy winds. Trees, branches, wire, and pole lines snap and fall, often blocking the track, and often destroying communication. However, the use of microwave radio and buried cables has lessened the severity of ice storms for railroads. Recovering from an ice storm requires clearing the track and keeping it open. Often full recovery from an ice storm takes several months.

A long period of heavy rain, sometimes combined with melting snow, can cause washouts and floods and destroy extended portions of track and subgrade. Track support may be lost as waters subside, leaving the subgrade soil saturated. Slides will then occur. Success and speed of repairs often depend on the accuracy and completeness of the initial estimate of the emergency - amount of damage, quantity of materials, machines and labour to do repairs.

Causes of train derailments and collisions may be due to human failure, track, equipment or signal failure, or a combination of these. Minor derailments can be handled with derailing irons and wedges, or a transversing jack. For serious accidents the wrecking crane is used. Track work involves clearing and restoring portions of damaged track, rebuilding the track, or building a temporary detour track around the wreck.

When hazardous substances are involved, with danger from fire or explosion, the wreck site may come under the control of local police or civil defense authorities. It is good to have pre-established working relationships between the railroad and the local authorities. Many urban transit properties have shown exemplary wisdom in their liaisons with fire and police authorities.

It is always important to determine the cause of the accident. For serious accidents, a survey of the accident scene is taken, including location features - distance to nearest curve, highway crossing, etc. - as well as features of terrain. The exact location of each derailed car will be determined. If defective track is a possible cause, a top-of-rail profile with deviations read to the nearest hundredth of a foot every 50 feet of rail length should be taken up to and beyond the point of derailment. This reading must extend 10 or more rail lengths back from the point of derailment to determine if any condition existed that might have started the derailment.

If there is any possibility of danger from an earth tremor, trains should be stopped and not allowed to proceed until a ground inspection has determined the safety of tracks, bridges, and tunnels. Where damage has occurred, the procedures are the same as for wrecks and washouts.

Accurate clocks play a part in preventing rail disasters and they are used to time signals and the movement of trains. The intensive operation of trains to a timetable that specifies the movement of trains to a fraction of a minute is only practical if rail staff have access to clocks accurate to 6 seconds. There is no substitute for precise clocks which are placed so they are visible to platform staff and train crew as well as signalmen. This is required to make the train timetable work effectively.

A conventional time distribution system has a time base, which is a quartz oscillator with a frequency of 4124 KHz. These vibrations are subdivided to give a cadence of one impulse a second or a minute. These impulses drive a reverser which supplies the power for the hands on slave clocks, which are driven by a master clock to avoid routine resetting. The voltage is usually 24, 48 or 60V.

CONCLUSIONS

Train derailments and collisions are usually due to human failure, but are also caused by inclement weather such as snow storms, ice storms, heavy rain, or even earth tremors. There are appropriate procedures for dealing with emergencies such as derailments due to these conditions.

Accurate quartz clocks, usually a master clock and secondary slave clocks are an important part of managing train timetables and accurate signalling. Therefore they have a role in averting rail disasters, especially collisions.

A drawback of the above articles is that they do not discuss emergency management with direct regard to rail passengers and their safety.

HUMAN FACTORS FOR
ACCOMMODATION IN VEHICLES:
CURRENT CANADIAN PRACTICE

TABLE OF CONTENTS

Introduction 2

Canadian Railroad Practice 3

Canadian Bus Practice 17

Canadian Ferry Practice 22

Canadian Yacht Practice 24

Canadian Travel Trailer Practice 53

Conclusions 30

BEHAVIOURAL TEAM, A CORPORATION
164 EGLINTON AVENUE EAST, TORONTO, ONTARIO M4P 1G4 (416) 482-5131

HUMAN FACTORS FOR ACCOMMODATION IN VEHICLES: CURRENT CANADIAN PRACTICE

Introduction

In this interim report we describe current Canadian practice concerning passenger accommodations on trips longer than 6 hours. There are several modes considered here:

* railroad,
* bus,
* ferry
* yacht, and
* travel trailer.

All of these different vehicles offer some sort of passenger accommodation. The details of the accommodation differ for the various operators and manufacturers. Different vehicles and different modes of transportation also have their own particular limitations. Each mode is described separately below. The "Taxonomy of Human Factors for Passenger Rail Design" provides the basic framework for each section.

Airlines are not considered in this report since there are few airplane trips in Canada that take 6 hours. A passenger could take longer than that for a trip with plane changes and stopovers. But most long duration flights are international. Consequently, current practice in air travel will be considered in the next next report on current international practices in travel accommodation.

Information for this report came from many sources. Published documents and available reports are listed in the bibliography. Other sources of information (eg. transportation company interviews, vehicle observations, etc) are described in the appendix.

Canadian Railroad Practice

I. GENERAL ENVIRONMENTAL VARIABLES

A. Temperature

In the seating coaches (coach and day-niter) the temperature is controlled by the conductor with a rheostat. A temperature between 68 and 74 degrees F is deemed desirable. The conductor can change the temperature based on passsenger feedback. Passengers may often be colder than the conductor since he is active and wears a uniform including vest and jacket.

Problems with heating or air conditioning are too common in the old equipment now in use. In a recent sample of passenger complaint letters, only on-time performance was criticized more frequently than problems with the temperature on the train (11% vs 9% of the total.) Much of the older equipment uses steam for heating and there are frequent mechanical breakdowns.

Rooms and roomettes have their own temperature controls. Berths have ventilator controls, but the temperature of the air coming from the vent is controlled by the train crew. The new LRC equipment has 2 HVAC units in each car plus baseboard heaters.

B. Air quality

Most of the older equipment used on long hauls have a fan in the roof plenum. In sleeping cars there are ventilator controls in all compartments. Rooms and roomettes may also have small wall-mounted fans. The fresh air intake is not subject to graded control based on temperature. If the outside temperature is very low, the fresh air intake is turned off. This is even the case with the new LRC equipment. This can result in very stale, and even smelly, air on long trips in cold weather. Air quality can reach its worst in coach cars at night when people take their shoes off. This is especially problematic since there are no bath or shower facilities on long train trips.

Cigarette and other tobacco smoke can build up to unacceptable levels, especially in the open sections (berths.) Smoke is also a problem in coaches, particularly when there are many smokers, low ventilation, or when the car is placed in the consist with the smoking area towards the front of the train. There have been many complaints in recent years, especially fom doctors and persons with allergies, about the annoyance of other people's smoke.

The LRC has a sensible design of putting the car's exhaust fans in the washrooms. This can decrease odour build-up in these areas.

C. Auditory stimuli

The noise level varies with the equipment. The Tempo cars seem to be the noisiest, since they have aluminum bodies and relatively uninsulated plywood floors. The older stainless steel cars are quieter, and the new LRC cars are the quietest. Although the LRC is also aluminum, it has sound insulation in the floor. No precise figures are available indicating noise levels.

Irregular noises are more bothersome to passengers than the running noises. Passengers are likely to complain about squeaks and rattles, especially in sleeping accommodations. Steel brakes have been replaced by friction brakes on most cars to reduce braking noises. The false ceiling in some day-niter cars rattles, and different moving parts in the sleeping cars may also squeak or rattle.

The LRC is quite quiet. On a recent trip Behavioural Team staff were able to converse at normal voice levels with other passengers across the aisle. Passengers wishing a private conversation would be required to lower their voices to a whisper.

The LRC also has a public address system. Pre-recorded announcements are made concerning stops and services. Some of the older equipment has switches for music and PA systems, but these audio systems are defunct.

D. Vibrations

On most trains, vibrations do not cause serious comfort problems. However, they may interfere with writing or other tasks. As is the case with noise, the Tempo cars are the worst long-haul equipment and the stainless steel and LRC equipment are generally satisfactory. Vibrations are worst over the ends of the cars, and over power equipment under the floor.

E. Accelerations

Starting and stopping the train are fairly smooth accelerations and decelerations. However, there is generally no warning that the train is starting or stopping. Passengers who are walking, standing, or changing position may have problems due to accelerations. These problems are more common when the train is underway. Small irregularities in the roadbed cause primarily lateral accelerations which may throw a passenger off balance. It is a common sight to see passengers having some difficulty walking on a moving train. From an informal sampling of some of recent accident reports on VIA, the most common category was falls while the train is running at a constant speed (about 20% of the incidents.) Only about 1% occurred during braking.

F. Lighting

Reading lights are provided on Tempo, LRC and day-niter cars. Several other types of lighting are provided in most cars. Flourescent lights, incandescent lights, and emergency back-up lights are used. During sleeping periods in coaches, the light levels are reduced considerably. In many cases, only every other ceiling fixture may be on, and these are turned to a low level. In some of the roomettes, there is a problem because the light is behind a person trying to look in the mirror.

G. Signs

There are numerous signs on the train. Most are affixed permanently, with the exception of advertisements, and signs indicating the direction to the dining or bar car. Graphic signs, sometimes accompanied by words, indicate the location of washrooms, first aid supplies, and smoking sections. Instead of the more common red cross on white, first aid supplies on the train are indicated by a white cross on a green background.

There are several proscriptive signs such as "do not flush the toilet while the train is in the station", "watch your step", "no standing in the vestibule", and the "no gambling, no spitting" signs which are only found in the men's washrooms. There are some newer signs from Transport Canada indicating that this passenger service is subsidized by the government.

There are large, plastic covered poster areas in the front of most cars. They generally contain a scenic photo with the VIA logo, some other VIA advertisment, or information about museum exhibits, etc. Recently, some other signs have appeared. They seem to be photocopies of advertising for VIA paraphenalia such as caps and carrying bags, taped to the wall in a vestibule.

Some cars also have a small thermometer placed at the front, on the wall.

H. Other visual stimuli

Different cars have different design features. Upholstery colours, carpet patterns, wall coverings, and other features vary. The colours tend to be somewhat dark, especially in the transcontinental day-niter cars.

The majority of visual stimuli for the passengers come through the windows. They are large and untinted in most cars, with blinds that can be drawn down from the top. In the LRC they do not have shades and are tinted. This makes it difficult to see out at night. In addition, the seats and windows don't always line up quite right in the LRC. Some seats have a better view than others.

In some of the older equipment, the washrooms have frosted or patterned windows, and, for some unknown reason, shades. The other windows in cars used in transcontinental service have pull-down shades. Their size varies from car to car. Most are about 24 to 26 inches high. The lengths go from 24 inches (beside a single row of coach seats) to 61 inches (beside a double row in the coach car). Windows in the berths and day-niter car are 41 inches long, while in the rooms they are 37 inches long. The windows in the diner are 22 inches high and 55 inches long. The dome car has special windows, as can be seen in the pictures opposite.

I. Space

1. Public spaces

There are several sorts of public spaces on long-distance trains. Each car has an aisle or gangway, vestibules at the ends, and one or more washrooms. There are other public spaces in other cars. The day-niter cars have larger washrooms, some of them with a washing and changing area separate from the toilet. Other cars have snack bars, lounges, observation areas, or dining areas.

2. Accommodation spaces

There are several levels of accommodation available in different cars on long-haul trains. The basic level is a coach seat. The next more expensive level is day-niter or club car. These seating arrangements are not mixed within a car. The day-niter cars have seats for 52 passengers and two crew members. The coach cars hold 72 seats.

In sleeping cars there is a mix of different accommodations. For the least expensive sleeping quarters a passenger can get a seat that converts to an upper or lower berth. The next level for an individual (or two people who don't mind being close) is a roomette. Bedrooms are available for various group sizes. The basic bedroom has two beds, and some pairs of bedrooms can be combined by opening the wall between them.

Some of the sleeping cars have 10 roomettes and 5 or 6 double bedrooms, while others have 24 roomettes. Only some of the cars also have berths (or "sections".) The cars that have sections have either 4 or 6 of them, along with 6 or 8 roomettes and 4 double bedrooms.

In some cars one of the bedrooms has more room and four beds. In the rooms, beds fold down from the wall, and the seats collapse to go under the beds. Roomettes contain a sink and toilet in the room, while bedrooms have the toilet in a separate small room. The berths share washrooms at the end of the car.

Sleeping car designs have been proposed for the LRC but there are none in service for VIA. Wheelchair tie-down systems are available on some LRC cars, and their implementation is proceeding in other cars.

II. BEHAVIOURAL VARIABLES

A. Boarding and leaving the train

Passengers board the train using a portable step on the platform and steps and handrails on the train. There is usually a train crew member to assist passengers. In a recent, informal review of about 100 accidents reported during July to October, 1983, about 10% involved stumbling, twisting an ankle, or falling on the steps. Another 12% involved similar mishaps on the platforms.

Boarding and leaving the train is often problematic for people in wheelchairs or stretchers. The receive special assistance from the crew, but not all kinds of mobility aids can be easily accommodated. Occasionally stretchers and wheelchairs have to be brought into a bedroom through the window. Only some of the windows can be opened in this way. In other cases, passengers with special mobility aids could only be accommodated in baggage cars because of the dimensions of their assistive device.

Other passengers with minor disabilities or encumbrences may also have difficulty. VIA has put particular effort into making staff aware of passengers' boarding and alighting needs, and ways that they can help.

B. Locating your "territory" on the train

Some of the "territories" on the train are assigned by reservation. These include berths, roomettes and bedrooms. Club car seats on the LRC are also numbered and assigned.

Other seats are picked on a first-come first-choice basis. On the older equipment, pairs of seats can be rotated to face another pair. Tables can be placed between the facing seats. This is often the preferred seating arrangement for groups of three or four people, or parents with children. The crew will turn the seats if requested but they don't encourage it.

Another aspect of choosing territory on the train involves the bar or lounge car. Some passengers get on the train early, plop their things down on a seat, and dash to the bar. There they monopolize a seat for most of the journey, often drinking alcoholic beverages in excess. This sort of "territory" strategy may sometimes involve groups of people acting together to retain control over "their" table in the bar car, even when some of them have to leave to relieve themselves of excess fluid contents.

C. Handling luggage

Passengers are allowed 150 lbs. of luggage for each ticket. On most long distance trains, some or all of this amount may be checked for carriage in the baggage car. Passengers do not have access to checked bags except under special circumstances. Additional baggage can be checked for more money. For example, you can take an extra 100 lbs from Toronto to Calgary for $70. The heaviest individual item is limited to 250 lbs.

Carry-on luggage is rarely screened by train personnel. There are rules and regulations about hazardous substances, personal liquor in open accommodation, and total weight of checked and carry-on luggage. But control is generally based on the "honour system".

There are open overhead luggage racks where passengers can store their belongings. In a sample of transcontinental equipment, these racks were 69.5 inches above the floor in day-niter cars and 75.5 inches in coaches. This is high enough to avoid head bumps by all but the tallest passengers, but it is out of easy reach for most passengers with moderately heavy bags.

The other dimensions for luggage racks in day-niter and coach, respectively, are;

	day-niter	coach
height	19-25 inches	16-19.5 inches
depth	32 inches	18 inches
lip	.75 inch	1 inch

The racks are covered with carpeting to prevent the bags from sliding. There are some other areas for baggage storage, such as ski racks on some winter trains. They don't hold very many skis, however.

Train crew can help people get bags into or out of the luggage rack, but they may be very busy during boarding and alighting. Many passengers prefer to keep their luggage nearby and in sight, so the floor is often crowded with bags. Other people use some of their baggage to save their seat, or to discourage others from taking an adjacent seat.

There are cupboards in the rooms and roomettes for storing some belongings, and hanging up some clothes. But passengers usually bring more luggage than there is room for, regardless of their accommodation on the train.

D. Activities in the accommodation space

1. Sitting

Sitting is the most common activity on long train trips. The seats vary depending on the accommodation. Sample dimensions for the different chairs and their distances are contained in the following table (all dimensions in inches);

	day-niter	coach	bedroom chair
seat height(front)	17	18.5	17.5
seat height(rear)	14	15	13
seat width	19	18	19

cushion height	4	5.5	5
seat depth	18.5	17.5	21
backrest height	32	30	27
backrest width	18	18	18.5
side armrests	3	2.5	(each) 2
centre armrest	2	none	-
pitch	51	41.5	-
aisle width	20	28	-

The newer seats in coach and day-niter cars have padded wings on the headrest to provide a more secure headrest for sleeping passengers. The seats in berths are upholstered benches. They are not as comfortable as other seats on the train.

2. Reclining

Seats in day-niter and coach cars recline, while those in berths, bedrooms, lounges, and dining cars do not. In the reclining seats, the seatback can vary from about -5 to -45 degrees from vertical. The passenger pushes a button on the armrest and leans back. The seat back will return to the upright position when the button is pushed and no backward force is exerted.

Footrests are provided for the reclining seats, on the seats in front. In addition, the day-niter seats have leg and foot rests which fold out from under the passenger's own seat. Use of the footrests on the seats in front can transmit movement to the passengers in front.

3. Reading

As mentioned above, reading lights are provided on some cars. On others, the general lighting level is adequate for most reading material during the daytime. Lights at night may be too dim for passengers to read comfortably.

Lights in the rooms are adequate for reading. Some have small, adjustable lamps. Some reading material may be provided for higher fare passengers. For example, magazines are provided in the dome car lounge.

4. Talking and social interactions

Talking and social interactions are common in all areas of the train, except perhaps the washrooms. (However, even the washrooms have been used as social spaces for some private interactions.) The train is traditionally a more sociable mode than air or bus. Several environmental conditions such as smooth ride, low noise level, spacious and variable seating arrangements, ability to get up and move around, group dining, and bars/lounges, contribute to the social atmosphere. Not so long ago, there was even a Canadian train that had a piano bar and group sing-alongs on some trips -- the memorable "Bistro" car.

At meal times, passengers may be seated with new fellow passengers. This provides an opportunity to talk with someone other than the people you're sitting near. During other times, passengers may go to other parts of the train, or move around to other unoccupied seats.

5. Playing games

Bingo games are held in the dining car after dinner on some routes. On long trips with a large enough number of children, one of the staff may organize some games for them. VIA playing cards are also available. Passengers may play cards in one of the lounge or snack areas, or in their seats. The tray at the seats is big enough for some, but not all card games. Tables can sometimes be placed between two pairs of seats to provide a larger surface.

Passengers sometimes bring their own games on board. This is particularly common for families travelling with children. They are encouraged to bring along things to keep their children occupied on long trips. Although VIA provides some forms of entertainment for children, they expect parents to be responsible for amusing their children. VIA has a few items for the children including paper hats and small cardboard trains that the children can assemble.

6. Sightseeing (looking out the window)

Sightseeing is another major advantage of train travel. VIA passengers spend a significant proportion of their time looking out the window. Taking pictures through the window is also popular. There are a few things that can interfere with sightseeing. If another nearby passenger wants the blind down, you may have to find another seat from which to see the sights. If the windows are dirty, it's hard to see out but there's not much you can do. VIA trains are cleaned regularly, but rain, dust, and spray from the wheels can quickly make the windows dirty again.

The windows are cleaned mechanically on the outside and by hand on the inside. This cleaning takes place before each trip, and usually once or twice during longer trips.

On the LRC, the windows are tinted with no shades. This makes sightseeing frustrating in low light conditions, such as at night.

7. Working

Crew members may have their paperwork set up on tables in part of the train. Passengers may also use tables in the seating, dining or sleeping cars to do work. The trays are large enough (10 by 14 inches with two cup holders) for some sorts of work but their placement is not ideal for most activities. A passenger has to lean forward to be directly over the tray. The trays are not sturdy enough to hold large or heavy objects. The trays in the Tempo cars were removed because they were not even stable enough to hold food and drinks.

8. Self care, and 9. Care of travelling companions

The space and facilities available for taking care of yourself and your travelling companions depends on your accommodation level. Coach passengers have their seat area, luggage racks, and small washroom/tiolet facilities. The day-niter and berth passengers have slightly larger washrooms. In some day-niter cars there is even a separate wash/change room with outlets for an electric razor. Roomettes have a toilet and basin in the room, but you can't use the toilet with the bed unfolded. Rooms have a basin in the room and a separate toilet. Both rooms and roomettes also have an AC outlet, but all of the passenger's AC outlets will only operate an electric razor, not a blower/dryer, curling iron, or clothes iron. There are no baths or showers in any of the cars.

Space in any of the accommodation can be somewhat restricted. Changing clothes in one of the berths could be difficult since you can't stand up. You can only stand around in the roomettes when the bed is folded up. The larger rooms can also be crowded when they have several occupants with their bags.

10. Sleeping

Some of the beds in the bedrooms are perpendicular to the line of movement of the train. The other passengers in roomettes, berths, and seats sleep parallel to the direction of movement. Some of the beds can be operated by the passengers, but those in the bedrooms usually require help from the train crew. This keeps the crew very busy in the early to mid morning and again in the evening. The passengers have to go somewhere else when their beds are being changed.

If the beds in a room are made too early, it makes it harder to sit around in the room. The chairs fold up and fit under the beds and there generally isn't room for both to be used at the same time.

Sleeping may be disturbed by the noises and movement of other passengers in the coach and day-niter cars. In the lower berths, the movements of the passenger above can be disturbing, especially if they step on your arm on their way to the washroom. The berths also permit more noise transmission than the enclosed spaces. Passsengers differ greatly in their ability to sleep under different conditions. Some can sleep for hours in a coach seat despite nearby snoring, talking, or babies crying. Others may not even sleep well in a bedroom. (Of course, some people don't even sleep well in their own bed at home.)

Bed sizes vary depending on the accommodation and the car series. The various sizes (in inches) are as follows;

Sections (berths)	38 X 74
Roomettes	33 X 74, 33 X 72, 32 X 74
Bedrooms	34 X 74

11. Intimate social behaviours (both positive and negative)

Intimate social behaviours can become a problem for other passengers who might disapprove, or would prefer not to be aware of them. On VIA trains, this has been most problematic in the berths. A couple there can have visual privacy, but their sounds may bother others in nearby berths. Some couples apparently use the washroom for such activities.

Negative social behaviours, such as fights and sexual harrassment, may also occur on the train. A crew member may interfere on his own initiative, or when requested by other passengers. If they are unable to resolve the situation, the police are called to come on board and remove the offending passenger at the next station. Disorderly conduct on the part of other passengers formed a small proportion (1.3%) of a recent tabulation of complaint letters to VIA.

12. Smoking

There are smoking areas in each seating car. The sleeping cars do not have special areas, people can smoke anywhere in these cars. Smoking is permitted in the dining car only during the last dinner sitting. Ash trays are provided in all areas where smoking is allowed. But people still use the floor too much for putting out their cigarettes, and burn holes in the carpet.

Smoking also accounts for a small portion of complaint letters (about 1.5%.) Unwanted smoke from other passengers can be particularly problematic in berths since there aren't "no smoking" areas and the berths aren't enclosed.

E. Transitions between accommodation space and public space

The rooms and roomettes cannot be locked from the outside. Although this generally doesn't cause problems, thefts could be a possibility. For this and other reasons, the sleeping cars are generally near the end of the train and coach and day-niter passengers are discouraged from walking through. Some of the doors open into the room while others slide into the wall. There are handrails for entering higher level roomettes and ladders for accessing the upper berths. On rare occasions, passengers have fallen out of upper berths.

The doors to the roomettes are only 17.5 inches wide. There is a curtain in addition to the sliding door, since there isn't room to fold the bed up with the door closed. Alternating roomettes in some cars are either upper or lower, depending on whether the bed is high or low. The upper roomettes have steps and handrails at the entrance.

The doors between the older cars can be rather hard to operate, especially if you are carrying something. The doors on the new LRC are power assisted, and operate with the touch of a large panel at foot or hand level. To prevent people getting caught in the door it also re-opens with pressure on the central areas of the rubber edge strip. The sensitive area of the strip doesn't extend all the way to the top or bottom. Sticking your foot into the door doesn't stop it from closing, but the closing force is not great enough to cause injury to an adult with closed shoes.

The armrests are the only aids in the seating areas for getting up and down. Many passengers, however, also use the seatback in front of them for support, although no specific handholds are provided here. Getting into and out of seats, roomettes and berths can pose problems for elderly or handicapped persons. They can usually be assisted by train crew.

F. Activities in common or public spaces

1. Aisles

Aisles in the older equipment vary from about 20 to 30 inches. This is not compatible with wheelchair accessability. The narrower aisles in the day-niter cars result from having wider seats. These aisles can create movement difficulties for passengers carrying luggage, two passengers moving in opposite directions, persons with mobility impairments, or for sleeping passengers whose arms or legs are hanging out into the aisle space.

2. Washrooms, toilets

On a train trip of 6 hours or more, nearly every passenger will need to use the washroom. Washroom facilities are provided in every passenger car. The rooms and roomettes have their own basin and toilet. Other passengers share public washrooms. Most of the washrooms are for males only or for females only, but a few of them are unisex. On the newer LRC, the washrooms are all unisex.

Toilets operate by lever handle or foot pedal on the older equipment and by push button on the LRC. Some of the towel holders and racks are quite high above the sinks (64 to 72 inches.) This puts the towels out of the reach of most children and other shorter persons.

For some reason, there often seems to be water (or other unknown liquids) on the floor of the washrooms. In addition, odours may build up in the washrooms, especially in stations, where the flush isn't to be operated. The washrooms in the Western Transcontinental are cleaned enroute by contract cleaners who ride back and forth between White River and Scriber. Other long-haul trains have similar arrangements. In addition the crew may clean the washrooms if they become aware of unsavory conditions.

Washrooms on trains are sometimes used for purposes other than those intended. Gambling, drinking, marijuana smoking, and sexual activities between two (or more!) passengers have been reported.

3. Lounges, snack bars and restaurants

Small snack bars are found in some cars. They sell various food items, some of which can be warmed in a microwave oven. Passengers then take the food back to their seats. In larger lounge/snack bars seats are provided and alcoholic beverages may also be sold for consumption in those seats. On long trips there is also a dining car. Meals are served in about 3 different "sittings" or time periods for each meal. The general operating hours of the dining car are 6 am to 10 pm. The passengers with higher fare tickets have the first choice of sittings.

The menu in the dining car has recently been reduced from 6 entrees to 2. But full meals are still served. This reduction in choices has led to some passenger dissatisfaction (about 7% of recent complaints dealt with meal service/quality), but it permitted a reduction of 2 in the galley staff. The dining car has 48 seats at 12 tables. The enclosed galley is nearby in the same car. There are no rails or handholds in the main section of the dining car, so passengers who lose their balance could end up with their hand in somebody's plate.

People often eat more on the train than they would at home. Passengers eat to socialize, or for something to do when bored. Full course meals at a single price also encourage more food intake. In addition, some passengers may monopolize seats in snack bar or lounge cars and drink large amounts of alcoholic beverages.

The LRC trains now in service generally provide food and drinks at the seats. In the coach car, this is done from a cart that is taken up and down the aisle by a crew member. In the club car, the crew person has a food preparation area at the end of the car and a bar in the middle.

G. General psychological considerations

The train offers several different levels of accommodation. Over the last 20 years or so there has been a reluctance to define these as "first class" and "second class", not only in trains, but in other modes as well. However, the passengers who pay more for their ride expect and receive better service than the coach passengers. In addition, they often do not wish to associate with the coach passengers. VIA takes several steps to insure this. The coach passengers are discouraged from walking through the day-niter and sleeping cars. Those with higher priced tickets have first choice of meal sittings. There are call buttons in the different enclosed accommodations to summon a porter.

Pets can be accommodated on any train with a baggage car. Pets are not permitted in the rooms or roomettes or elsewhere in passenger areas. Passengers usually have the responsibility for feeding and watering their own pets, and walking them at stops. Typically only dogs or cats are brought on a train trip, but birds and other pets may be checked occasionally. Seeing eye dogs are allowed to accompany their owners anywhere on the train.

Efforts are made to inform passengers before their trip about rules and constraints. Some of this information is provided by the reservations agent or baggage person over the telephone. In addition, there is a small pamphlet given to long-haul passengers to familiarize them with the train and its services. The approach tends to be somewhat hit-and-miss, however. Communications and misinformation were cited in about 14% of a recent sample of complaint letters.

III. INTERACTIONS WITH RAIL PERSONNEL

The same tabulation of complaint letters indicated that about 11% of complaints were about crew behaviour. Common problems are unavailability of a crew member when minor assistance is required, and unfriendly or unhelpful demeanor toward passengers. The crew receive some special training in good passenger relations, but this could be improved. Some staff problems may relate to the fact that crew can be employees of VIA, CN or CP. Other problems may relate to demands to be "on call" at all hours on overnight trips. Crew usually work in pairs to try to get at least 4 hours of sleep on overnight runs.

There are no "call" or "alarm" buttons in coach or day-niter cars. If there is no crew member nearby, a passenger in distress may have to go searching for a staff member, or ask another passenger to go find help.

There are other human factors problems that mainly affect the crew. The major one is lack of space for storage. There is not enough space for storing used linens and bags of garbage near the end of long trip sections. If a porter misses a garbage drop-off, bags of garbage may be left in corners and aisles, or may fillthe porter's own quarters.

Staff may occasionally be called upon for controlling rowdy, drunk, or aggressive passengers. This is a difficult task for anyone. Female crew members may have particular difficulty with this duty, as well as with some of the heavier physical tasks such as loading food onto the train.

Interactions between staff and passengers have improved considerably since VIA took over passenger services. Continued efforts are needed to optimize passenger satisfaction without overburdening the crew.

Canadian Bus Practice

I. GENERAL ENVIRONMENTAL VARIABLES

A. Temperature

Temperature is kept at a constant 70-72 degrees by Graycoach, with no seasonal variation. Voyageur keeps their coaches at 65 degrees, and a bit warmer than this in the winter. On Greyhound coaches, the temperature varies seasonally, due to the use of air conditioning. Sometimes the temperature is changed at the request of passengers.

B. Air quality

Greyhound buses have fresh air intakes and interior exhaust vents. Graycoach buses supply 20% fresh air and 80% recirculated air regularly. Voyageur buses have a recirculatory system which replaces the air every few seconds. The windows do not open on any of the buses due to the air conditioning.

C. Auditory stimuli

Voyageur buses are quieter at the front and noisier at the back. Graycoach estimates the noise on coaches as 72 dB(A) maximum. The Greyhound representative interviewed could not offer an opinion.

D. Vibrations and E. Accelerations

Graycoach said that there is no problem from vibration or acceleration since passengers are seated before the bus begins to move. Voyageur said that acceleration and vibration depends on each individual driver's handling of the bus; normally there is no problem. Greyhound said that there is very little problem from acceleration and vibration.

However, passengers are more likely to experience walking difficulties from lateral accelerations on a moving bus than a train or plane because of irregularities in the road surface and changes in the direction of travel.

F. Lighting

New buses have individual reading lights. There are also interior lights controlled by the driver when passengers board and alight and when stopping at rest stops. At night there is dim illumination for walking to the washroom.

G. Signs

Greyhound buses have signs restricting smoking, the use of alcohol, warning to remain behind a marking on the floor when the bus is in motion, and that the vehicle is restroom equipped. Graycoach buses have a no smoking sign, driver regulation signs, and signs that there is air conditioning and a washroom aboard. Voyageur buses have desination signs, a sign not to stand in front of the white line at the front of the bus, and a sign prohibiting smoking in the front five rows.

H. Other visual stimuli

The interiors of long distance buses are not remarkable. There is little room for decorative touches. The visual stimuli consist of the upholstery, floor, ceiling, other passengers, and, most importantly, windows. The windows afford the passengers a good view of the passing scenery and a "superior" view of the cars on the highway. Some of the passengers can also see some out the driver's windows. This may not always be a relaxing view.

I. Space

1. Public spaces and 2. Accommodation spaces

The aisles and washroom are the only public spaces on buses. And the seat and its surrounding area are the only accommodation space offered.

On Greyhound buses the aisle width is 15 inches; the distance from the front of one seat to the back of the next seat is 15 inches; the space under the seat is 12 inches high; seat width is 18 inches; and there are 43 seats on some coaches and 47 on others. All seats have a headrest and footrests. There are windows and aisle armrests but no centre armrest in the double seats. The floors are covered in vinyl linoleum. Graycoach and Voyageur could not provide any interior dimensions, but they are about the same as on the Greyhound buses since the number of seats is standardized on most coaches.

Prevost Car Inc., a Canadian bus manufacturing company, has recently designed a wider, 47 seat, 40 foot long, 102 inch wide bus (the Marathon X-L) to give additional passenger comfort and to adapt to changing market needs.

The double seats on each side are 1 1/2 inches wider. The extra width enhances cargo space and allows enlarged seats for extra passenger comfort. The extra width also helps in the stability of the bus and gives better suspension.

Other features that are being incorporated in the new buses for passengers' physical and psychological comfort are: extra soundproofing, with noise inside the bus being kept to 78 dB(A); a lighter bus than the 96 inch model; better gas consumption; better insulation; improved climate control due to the increased space; windows enlarged at the top for better passenger vision; enlarged overhead luggage racks; and a larger washroom.

Prevost offers several materials for floor coverings and seat coverings as options to the operator. Hallsworth and Firth materials made out of wool and nylon are offered as seat covering options and carpet, vinyl, and linoleum are offered as floor covering options.

II. BEHAVIOURAL VARIABLES

A. Boarding and leaving the bus

There is often a fairly high step to enter the bus. On some transit services, "kneeling buses" and fold down steps have been tried. On long distance bus runs, the driver or some other staff person usually helps people board and alight.

B. Locating your "territory" on the bus

Seats are not assigned. The first to board get first choice. There is only one type of seat, so the choice is limited to the front, "no smoking" section, or the rear "smoking" section.

C. Handling luggage

Greyhound allows each passenger three pieces of luggage. Voyageur allows two pieces of luggage, and Graycoach allows "any amount within reason." Luggage is checked to the destination and carried in lower compartments accessible only from the outside of the bus. Passengers also bring on carry-on luggage which occupies space on floors and seats, as well as luggage racks.

D. Activities in the accommodation space

The options for passenger activities on the bus are rather limited. Passengers can sit up or recline slightly, look out the window, look around inside, talk to persons nearby, or walk to the washroom. Some passengers can read but others experience motion sickness in buses if they read for long.

The windows on Greyhound buses are 30 x 54 inches. The buses of all three companies interviewed are tinted. There are no shades or curtains. The windows of all buses are cleaned inside and outside every time they are in the garage.

On all buses, seats recline for sleeping. Other than that, no special provisions are provided for sleeping except for Graycoach which provides pillows.

Smoking is allowed on Greyhound buses; smokers use the floor for butts. Voyageur reserves the front five rows for non-smokers; ashtrays are provided to smokers. Graycoach reserves some seats for smokers and ashtrays are provided.

E. Transitions between accommodation space and public space

Passengers may use armrests or the back of the seat in front to stabilize themselves for entering and leaving their seats. No special handholds are provided. The washrooms have doors which can be locked from the inside.

F. Activities in common or public spaces

1. Aisles

The narrow aisles on buses are barely adequate for one person walking without luggage. Carrying things, or meeting another passenger coming the other direction, or stretching your foot out into the ailse when you sleep can cause problems.

2. Washrooms, toilets

Buses on all three lines, both day trip and overnight buses, have toilets.

3. Lounges, snack bars and restaurants

Voyageur and Greyhound do not provide food or drink on board their buses. Rest stops are made during longer trips for this purpose. Graycoach have three coaches which have an on-board galley which provides food and drink.

G. General psychological considerations

The Graycoach representative interviewed claimed that the buses are very safe and that there are no mishaps. Voyageur similarly claimed a good safety record. However, occasionally luggage falls from the overhead racks or someone falls when going down the aisle to the toilet. Greyhound says that sometimes a passenger stumbles getting on or off the bus, but the driver is there to assist by the door.

Graycoach provides background music on some coaches. Neither Voyageur nor Greyhound provide any form of entertainment for passengers.

None of the bus companies make special provisions for mothers travelling with infants. However, Greyhound makes no extra charge for the infant.

Graycoach and Greyhound both allow seeing eye dogs to travel on their buses. None of the three bus lines allow other pets or livestock to be carried.

III. INTERACTIONS WITH BUS PERSONNEL

On Greyhound, a wheelchair can be stored in the lower luggage compartment and the disabled person is assisted in boarding. Free transportation is provided for the escort. Voyageur buses do not accommodate wheelchairs, but facilities are provided to help disabled passengers board and disembark. Graycoach buses can accommodate folded wheelchairs in the lower luggage compartment and disabled passengers are assisted on and off the bus.

Canadian Ferry Practice

Consulting naval architects ensure that the air requirements on board CN Marine ships are done to industry standards. For cruiseships a good, medium temperature in public spaces is always desirable. It is reported that unsightly ventilators are a thing of the past. The volume of air and the temperature in the sleeping areas is best controlled by the passenger himself.

The lighting ambient is done to industry standard where it is worked out by consulting naval architects.

To create a change in atmosphere throughout the different facilities and provide an outlet to relieve boredom on the long ferry voyages, CN Marine maximizes the use of decor elements.

Although CN Marine has indicated that they are not in the cruiseship business, they do not overlook the fact that they carry 1.25 million passengers during the tourist seasons which accounts for about 60% of their total carrying for the year.

It is important to have fast access and egress between accommodation and vehicle decks, as well as between ship and shore especially during the tourist season of July/August. For recent construction and latest major refits, particular attention is being paid to circulation onboard including ease of access for those with mobility problems.

CN Marine allows fairly generous spacing between seats and in access passageways -- as a rule of thumb, one passenger per square metre of total lounge space. This allows passengers to have a sizable "territory." CN Marine does provide a travel seat for every passenger on board when the run taken is during the tourist season. Travel seats are defined as those other than in restaurants, bars, games rooms or other activity areas.

CN Marine provides reclining day-niter seats to its passengers for a slight extra charge. In the large seating lounges, CN Marine strives to physically arrange the seats so that they are not row upon row, but rather in groupings for conversation or family activities.

Some of the seats are arranged theatre style and oriented towards a wall-mounted television set. The various groupings in the lounge section are distinguished by the use of different coloured upholstery to create a visual delimitation.

In general, CN Marine has no on-going program of activities - as one might find on cruiseships - so passengers tend to wander about the ship a lot.

CN Marine report that the comfort level, which is determined by sailing time, will vary from ship to ship. For a run that is less than three hours, the fast food service with appropriate seating is a suitable level of service. Also, it is not essential for the number of seats on the ship to equal the total potential number of passengers on short trips.

When the sailing time is over three hours, CN Marine provide cafeteria or full meal service with proper restaurant tables and chairs. The seats are high backed with arm rests.

Over a long period of time, plush, soft seating which is perceived to be quite expensive, is not desirable for support. Firm seating is much more "comfortable" and it adds to the life, beauty, and cleanliness of the upholstery being used.

The designers of cruiseship take into account the safety aspect in all areas of the ship. Among other things, they ensure that all areas have clear and easy egress, that the exits are well marked, and that the steps are well lit.

Although a relaxed mood may be appropriate in certain lounge areas, a good level of lighting with the appropriate and well placed emergency lighting is necessary. In addition, all materials used must have a high flame-spread rating (Class A) or be completely non-combustible. This rule applies to foam seating construction, upholstery, wallcoverings, bulkheads, and carpeting.

Whenever possible furniture should be fixed to the deck or bulkhead. This ensures that passengers are not maimed. The passageways should be constructed so as to ensure safety when using them. Easy manipulation of opening and closing doors is also important to avoid harming the passenger.

Canadian Yacht Practice

I. GENERAL ENVIRONMENTAL VARIABLES

A. Temperature

Most yachts (either sail or power) do not come equipped with temperature control systems. Since yachting in Canada is generally restricted to times of moderate to warm weather, additional heating is not required. When heating is necessary, it is provided by electric or catalytic heaters. Electric heaters are powered by the boat's generator or by AC power from shore. Engine heat is sometimes used for heating water but not for controlling living compartment temperatures. Some fuel powered heating systems would be dangerous on boats since they could tip over due to boat movement. On-board cooking equipment may also be used for raising the temperature, but this affects air quality.

Likewise, air conditioning is also uncommon on Canadian yachts. Air temperatures on the water do not reach high levels even on hot summer days. Individuals may install small air conditioning units on their boat if they plan to live on the boat at dockside. But Canadian manufacturers do not provide air conditioning.

Temperature in the passenger accommodation area is, therefore, determined primarily by the ambient temperature. Body heat, cooking, using hot water, and opening doors (hatches), windows (ports) and vents will also affect the temperature. Proper clothing is very important for controlling body temperature on yachts in both hot and cold (and, especially, wet) weather.

B. Air quality

One of the often cited pleasures of yachting is the "fresh air" out on the water. In good weather on a moving boat with ports open, the air can, indeed, be quite pleasant. On the other hand, when the craft is at dockside with diesel exhaust and mosquito repellant wafting through the air, the air quality may be less than ideal. Ventilators or fans are not common on boats. The relatively small interior compartments mean that smoke, smells from the galley and head, and stale air can be a problem when the air is not well circulated. Larger craft usually have at least one overhead air vent, or screened opening ports.

C. Auditory stimuli

The sounds encountered in travelling by yacht include noises from the engine, generator, and other equipment, and the sounds created by the boat's impact on the water. The sails and rigging on sailboats also generate noises. Sound insulation is generally provided for the engine and/or generator, and ballast or flotation materials may absorb some sounds from the hull striking the water. The level of noise experienced by the passengers thus depends on the particular equipment and operating conditions. No precise data is available on the noise level in different yachts.

Additional auditory stimuli include radios, tape decks and the sounds generated by fellow passengers. Doors between compartments, interior carpeting, and other furnishings reduce noise transmission. A boat at anchor with no engine or generator noises may be so quiet that auditory privacy is impossible without adding masking noises (eg. turning the radio on.)

D. Vibrations

Vibrations come from the engine or generator, or in rare circumstances, from transmission of the vibrations of a sail. Power equipment is usually mounted in a manner designed to reduce vibration. However, annoying vibrations may still be transmitted to some parts of the boat. Since the boat is on the water, vibrations from movement across the substrate do not cause much of a problem.

E. Accelerations

Accelerations on ships and boats cause two major human-factors problems. First, like all other modes of transportation, variable accelerations make movement within the vehicle difficult or hazardous. The high amplitude of accelerations on a craft moving through the water may not only cause a slip or fall, but may even cause a passenger on deck to fall overboard. The expression "sea legs" describes the stance and gait modifications required to move about during large movements of the craft. Rails and handholds are often provided both on deck and below to help deal with these accelerations.

In addition, the low frequency accelerations may lead to "sea sickness". Although milder forms of motion sickness may be experienced in airplanes, cars or buses, they cannot compare to the totally debilitating effects of sea sickness. Individual people may be more or less susceptible to motion sickness. Other visual and postural activities can potentiate or diminish motion induced malaise. For some passengers, drugs such as dramamine may provide the only protection. These interfere with alertness and performance, however.

F. Lighting

There are several lighting systems on most yachts. Some outside light comes in through the ports, but these are usually small. Windows on power craft are generally larger than on sailing yachts. In addition there are running lights, interior lights that are powered by a generator or by batteries charged by the engine or generator, and connections for running the lights from shore-supplied AC power.

The most common locations for lights are the captain's desk, the cooking area, the washroom, the dining area, and the sleeping quarters. They tend to be small lights that can be aimed to optimize energy use.

G. Signs

Yachts are quite variable in terms of the signs onboard. Passengers generally encounter few signs. The stove and plumbing may have instructions. But the most common signs are humourous ones concerning issues such as coctail time or the captain's authority.

H. Other visual stimuli

The interiors of yachts currently being produced in Canada vary from bare fiberglass with nylon hammocks to oiled teak woodwork, antique furniture and expensive upholstery. The price varies accordingly, with yachts ranging from under $10,000 to over $500,000.

I. Space

1. Public spaces

The common or public spaces on a yacht include the deck, the main cabin and the washroom (head.) The amount of usable space depends on the size and price of the yacht.

2. Accommodation spaces

In a recent yacht show (Dockside '83, Toronto) Behavioural Team had the opportunity to inspect over 50 different models. The 18 to 29 foot yachts generally sleep 4 or 5 passengers. In the more expensive models, there is a separate cabin for two, with the other two or three persons sleeping in the main cabin. In almost all models, the dining table and benches convert to a bed. The 30 to 40 foot models sleep 5 to 10 passengers. The larger craft have up to three separate cabins. Manufacturers suggest that the number of passengers should be based on the length of the trip and the intimacy of the passengers. Quarters are obviously close.

Headroom is often limited in part or all of the cabin interior. Maximum headroom is sometimes under 6 feet while minimum headroom in walking spaces may be under 5 feet.

Single berths for adults range from 70 to 78 inches long. The width varies from 32 to 36 inches. Double berths are often in the front of the cabin and are shaped like a truncated triangle. Several samples measured as follows (in inches):

width at the wide end (aft)	72 - 92
width at the narrow end (fore)	6 - 22
length at the centre	75 - 83

II. BEHAVIOURAL VARIABLES

Yachts used for all day or overnight trips are generally designed for small groups of close friends or family members. For extended voyages, compatability in close quarters is essential. Yachts try to use every square inch of the available space. The shape of the transportation envelope, and the importance placed on operational features places some constraints on the design. More expensive yachts are generally more comfortable as well. But speed and handling features often receive more emphasis in the advertisements.

Many of the passenger activities, such as reclining, sightseeing, and sometimes even sleeping occur on deck. The cabin is the main centre of activities at night and in inclement weather.

There are particular problems that are inherent to yachting. One is limited storage space. Separate storage is needed for wet and dry gear. The exterior is designed for the able-bodied. The interiors have steep, small steps, and small passageways. A person in a wheelchair couldn't get around easily, and other disabilities would pose problems. There is usually not enough space inside unless you're very rich and/or don't have many friends.

There are a few interesting design features in some new yachts that might be useful in other modes. One is a combination shower and toilet. Both are in the same small compartment which has a grid floor (usually cedar) and a drain underneath. Another is bunk beds placed at an angle so that only the foot of the lower bunk is under the upper bunk.

In general, however, the interior of yachts is more similar to travel trailers than to other accommodations. Both are designed for groups of family or friends and contain cooking and eating facilities. In both cases, much of the passenger activity is intended to take place outdoors.

Canadian Travel Trailer Practice

Obtaining information about recreational vehicles, including travel trailers, mini motorhomes, and motor homes was a difficult task. A list of manufacturers was obtained from Industry, Trade and Commerce and letters were forwarded to a sample of about a dozen manufacturers asking for pertinent information. We did not receive any written response.

We proceeded to call the Canadian Recreational Vehicle Association to ask for further direction and we were informed by the Executive Assistant, Harold Young, that a number of the firms that we had contacted were no longer in business and that the list was not up to date. Despite these setbacks, we were able to obtain some information on travel trailers as a mode of accomodation.

Patrick Yee, a senior engineer certifying recreational vehicles with Canadian Standards Association, informed us that the layout of travel trailers is determined by the individual manufacturers and is not subject to any standard regulations. Included among the various governing criteria that the standards association is responsible for are:

- a maximum width 8'6" and a maximum length 36' or 11 meters above which special signs must be posted

- an entrance on one side of the vehicle and an emergency egress on the other side.

To answer some of the relevant accomodation questions we contacted Norm Smith, at Fleetwood Manufacturing Ltd. (Lindsay, Ontario). Since travel trailers are towed vehicles, he informed us that it is not legal to occupy them when the vehicle is in motion. Therefore the issues of ventilation, acceleration, noise level, vibration and safety in a moving vehicle are no longer applicable. However, we were provided with some input on the kinds of things that are available in the enclosed accomodation space of a travel trailer.

The Living Room Area

The living room area has a combination of these accomodations: a sofa-bed or lounge which reclines and can be used as a sleeping area, a table, free standing chairs, a magazine rack, and T.V. sheives.

The Bedroom Area

The bedroom area includes a queen size bed, two night tables, a built-in dresser cabinet and a wardrobe cabinet area. The area underneath the bed is used as storage space.

Washrooms

The average washroom includes a combination bath-shower facility, a sink with a cabinet providing storage space, toilet facilities and a medicine cabinet. In order to manintain sanitary conditions over the course of a long trip, the facilities include 2 separate holding tanks, one for waste from the toilets and one for waste from the sink. This waste can then be dumped at appropriate dump sites when a camp is reached. The controls on the various bathroom pieces are miniaturized but not necessarily different from the controls of a normal washroom. One interesting use of the bathtub would be for storage space of odd shaped baggage which does not fit in designated storage areas (i.e., bicycles).

The Kitchen Area

The kitchen area includes a sink or sinks with hot and cold water, an oven-range combination that runs on gas or electicity, and a power range hood for the exhaust fumes. A refrigerator and extensive storage cabinet areas are also provided. Included is a dinette area with two bench seats and a table. The bench seats can be converted into a sleeping unit by lowering the table to the height of the seats. The backs of these benches do not recline. The height of these seats are about 18" off the ground and the base can be used for storage.

Construction

The travel trailer varies in average width and length. It is usually under 8' wide and averages 25' in length. Aside from furniture and cabinets a floor space of up to 50-60 sq. ft. may be available. Every available space is used to its maximum capacity and there is considerable storage space in all areas of the trailer. Additional storage space can be added to the back of the trailer, as outside storage bins. Some trailers have roof storage accessed by a portable ladder.

Although it is possible to obtain trailers that sleep from two people to ten people, a six sleeper is the size most commonly requested. Larger models may have separate rooms, but many smaller models sleep 2 to 6 persons in a continuous interior space. The beds are sometimes made more private with curtains.

The floor covering is vinyl and linoleum although there is an option for carpeting bedroom and living room areas in the larger models.

The windows in travel trailers are of different sizes ranging from 15 x 24 to 24 x 72 inches. Generally plain glass is used. In some cases, although this is rare, tinted glass is used. A combination of shades and curtains can be found on the trailer. Roller shades may be more common to the bathroom and kitchen areas whereas the bedroom and living room areas may have curtains.

A special and mandatory safety feature is having two exits. The emergency exit is often an escape window and it is located at the opposite end of the trailer from the normal entry door.

Conclusions

This report describes some basic features of different sorts of moving accommodations in Canada. The level of information available varies. We have concentrated on getting relevant information from VIA concerning their current practices. The most comparable level of information comes from buses, since the transportation aspects of the two modes are similar. Information from ferry service has also been included, but precise data was not available at the time of this report. The information from private yachts and travel trailers relates primarily to the design of bedroom accommodations on the train. Other features of yachts and travel trailers are of limited use in the design of passenger rail cars.

The next task for this project involves a review of international practice for enclosed accommodation, especially on trains. The task following that calls for the integration of the international and Canadian data with regard to design practices for trains. The main discussion and analysis of the accommodation data will constitute Interim Report E.

The present review indicates that VIA's long distance trains compare favourably to other modes of vehicular accommodation in terms of comfort, space and safety. The trains offer somewhat less space per passenger than long distance ferry services in Canada. But even VIA's older trains offer considerably more space, service, and options for activities than do Canadian bus services. Yachts and travel trailers provide some useful ideas for enclosed rooms on the train, since all are usually designed for a small group of friends or family members.

Human Factors for Passenger Rail Design: Current International Practice

TABLE OF CONTENTS

A. INTERNATIONAL RAILWAY PRACTICE

I. GENERAL ENVIRONMENTAL VARIABLES.............................. 2
II. BEHAVIOURAL VARIABLES....................................... 8
III. INTERACTIONS WITH RAIL PERSONNEL..........................17

B. CURRENT AIRLINE PRACTICE

I. GENERAL ENVIRONMENTAL VARIABLES..............................18
II. BEHAVIOURAL VARIABLES.......................................21
III. INTERACTIONS WITH AIRLINE PERSONNEL.......................26

C. CRUISESHIP PRACTICES

I. GENERAL ENVIRONMENTAL VARIABLES..............................27
II. BEHAVIOURAL VARIABLES.......................................29
III. INTERACTIONS WITH CRUISESHIP PERSONNEL...................32

BEHAVIOURAL TEAM, A CORPORATION
164 EGLINTON AVENUE EAST, TORONTO, ONTARIO M4P 1G4 (416) 482-5131

HUMAN FACTORS FOR PASSENGER RAIL DESIGN - CURRENT INTERNATIONAL PRACTICE

INTRODUCTION

This interim report deals with current international practice in long duration travel. Three modes of transportation are considered - trains, airlines, and cruiseships. The information about these modes has come from written reports, interviews, and first-hand observations. We have tried to get information from some of the leading carriers in each of these modes. We made particular efforts to review the equipment and practices of several leading European railway companies, as well as including information from the USA and Japan.

In general, we have not covered the practices in most "third world" countries. They often have levels of crowding and discomfort that would not be acceptable in Canada, and their equipment usually consists of coaches and locomotives that have been retired from service in more developed countries. Thus the Manchester division of the British Broadcasting Corporation (BBC) has recently produced a television series entitled "Great Railway Journeys of the World." This series covers the range of railways from old steam powered trains still operating in places such as India and Peru, to the modern trains of Europe. This series clearly shows that only the most modern equipment has taken human factors issues into account in a systematic fashion.

A. CURRENT RAILWAY PRACTICE

I. GENERAL ENVIRONMENTAL VARIABLES

A. Temperature

In most modern rail coaches the temperature maintained inside depends on the outside temperature. For moderate outside temperatures, an inside temperature of 22 ± 2°C is deemed desirable in coaches. Sleeping cars usually have some passenger control allowing the temperature to be lowered to about 15-17 or raised to 24-26°C. Modern coach cars have temperature controls which are only accessible to train crew. The temperature can be changed based on passenger requests, but the crew person may check with other passengers first to see if there is some consensus. With outside temperatures below 0 a temperature of 18-20° may be considered adequate, however passenger preferences depend on amount of clothing, time on the train, etc.

In most cases, air conditioning is provided to lower the inside temperature during hot weather. Sweden is an exception to this case, since the short periods of hot weather there make air conditioning uneconomical. In other countries, the inside temperature can go up to 30ºC in air conditioned cars when the outside temperature reaches mid 30s. The Swiss (SBB) try to maintain a temperature in air conditioned cars that is halfway between 22º and the external temperature.

B. Air quality

The main problem with air quality is cigarette smoke. For many of the most advanced systems (Switzerland's EW IV coaches, Denmark's Lyntog, and some cars of France's TGV) smokers are in a separate coach or closed section of coach. In the Swiss (SBB) coaches, all of the air from the smokers' section is exhausted, with the recirculating air all coming from the non-smokers' section. In cars seating both smokers and non-smokers (eg. second class TGV coaches), circulation is designed to reduce the amount of smoke entering the non-smokers' section. But this is never completely successful, we have observed.

The SBB provided the most comprehensive description of their air circulation designs. Air is exchanged 20-25 times per hour. The total rate of air flow is 3400 m^3/hr with over half fresh air (1720 m^3/hr.) As mentioned above, all of the recirculated air is from the non-smoking section. Warmer air is introduced through vents near the floor at rates of up to 1000m^3/hr, with the remaining air at a cooler temperature coming through ceiling vents.

For other railways, rates of air exchange and proportions of fresh air vary. At very low temperatures, there may be little or no fresh air. For example, the Swedish Railway (SJ) claim to exchange the air inside coaches 25 times per hour, but below -10ºC none of the air is taken from the outside. However, it is still possible to open half-drop windows in most Swedish coaches to let in some fresh air. The newer French (SNCF) coaches have 20-25% fresh air in each air exchange except on some special "snow routes."

Most European railways rely on UIC (Union Internationale de Chemin de Fer) guidelines concerning temperature, ventilation, noise and vibration levels. These guidelines are comparable to the AAR guidelines used in North America.

In general, it is not possible to open windows in air conditioned coaches or cars. In the new high speed trains such as France's TGV and Japan's Shinkansen, there are also aerodynamic and safety reasons for not opening the windows. In cases where windows do not open, there is generally a small hammer available for breaking the window in emergencies.

Windows typically open by the top half sliding down in front of the bottom half, or a smaller upper section opening inward on hinges to stops at 45 degrees. In some trains, such as Denmark's Lyntog, the hinged windows can be locked with the standard square key used by European rail crew.

C. Auditory stimuli

The noise level guidelines of the UIC specify no more than 68 dBA in second class coaches operating on good track at 160 km/hr. The corresponding figure for first class is 65 dBA. These figures are not always achieved in practice due to track irregularities or specific situations such as braking or passing another train or a tunnel. Newer equipment and some refurbished stock have disc brakes which are quieter.

A recent sampling of noise levels on several European railways conducted by Behavioual Team generally gave results of 62-72 dBA while running. This included the TGV (SNCF), Talgo (RENFE), and several TEN sleeper cars (SNCF and DB). The Swiss Railway (SBB) indicated that the lower sound levels in some of their new saloon coaches, sometimes <62 dBA, is too quiet. Additional sound barrier and sound absorbing materials are required on the ceilings to prevent passengers' conversations and noises from travelling too far.

For the same reasons, the French TGV open coaches were designed to have conversations limited to about the same spatial spread as the older compartment cars. They have a noise level below 70 dBA while operating at up to 270 km/hr.

Modern European trains usually have a public address system of some sort. In some cases it can transmit train station announcements as well as announcements from the train crew. The announcements are often in more than one language. One Talgo train in Spain had the same announcement presented in Spanish, Portugese, French, English, and German.

Train companies recognize that passengers want information about any stops or delays in schedule. Scheduled stops are usually announced but delays are seldom explained.

Attempts to provide music to passengers in their rooms and seats has not met with much success. Not all passengers want the same music or like the same volume. Providing individual music is more expensive but still has its problems. In the most recent effort in Denmark the DSB put small speakers and controls in the headrest wings near the passengers' ears. The automatic volume control system, meant to compensate for changes in ambient noise level, has not met with passenger approval. In the next series of Lyntog trainsets the DSB plan to have airline-style earphones or no individual music.

D. Vibrations

Vibrations are not a severe problem on most European trains. Long distance trains generaly provide a physically comfortable ride in terms of vibrations, but certain activities can be problematic. Writing is sometimes difficult, as are other fine motor tasks based on a fixed table or tray.

On the TGV from Paris to Dijon the vibrations were the worst of several routes sampled. They caused drink bottles to fall off of the table between rows of seats. The return TGV trip was smoother. More vibrations can be tolerated on the TGV since its trips are generally less than four hours. The seats for the TGV and their attachment to the floor were the subjects of special design studies. The seats were designed with exposure times of 6-8 hours in mind.

Vibrations tend to be greatest over the bogies. To reduce the amount of coach space which is above bogies, both the TGV and the Talgo have shared bogies between adjacent coaches. This reduces consist flexibility to some extent.

E. Accelerations

There is little noticeable heave, or up and down acceleration, on most modern trains. The shunt forces (front and back accelerations) are limited to very low levels except during emergency braking. Decelerations of 1.5 to 2 meters/sec/sec can occur in emergencies, but this would cause problems for passengers who are standing or changing positions. Normal accelerations and decelerations are less than 1 m/sec/sec.

Lateral accelerations, or sway, also cause problems for passengers who are walking or in other unstable positions. Handrails along the windows and graspable seat backs provide some assistance. In some cases the window rails are designed to keep passengers in the train in a major calamity but they may also prevent minor mishaps. New Swiss coaches were designed with hand holds on the seat backs. All of the equipment has hand holds in the toilet compartments.

High frequency sway is also a problem in many European sleeper cars, especially if your stomach is overly filled with food and drink.

Attempts to reduce accelerations on curves by tilting the coach body have had many problems, not only for the LRC. Apparently the only tilting mechanisms that are working today are the passive tilting of the Talgo III and the Japanese 381 trains. The SBB think the technical problems can be solved but it is not economical for them to implement the solutions when it only saves 10 minutes on the run from Zurich to Geneva.

F. Lighting

Flourescent lighting is usually provided in the centre of open coaches or compartments. In some cases indirect lighting or lights mounted under luggage racks are used. Incandescent reading lights are sometimes provided in first class seats. All of the reading lights in European trains have a fixed aim. Many of them only work when the main lights are turned down.

Lights in open coaches are generally on all of the time. The lights in compartments and bedrooms can be controlled by the passengers. The lower level lights in compartments and bedrooms vary from dim incandescents to brighter lights behind small apertures. Often the lower lights do not work. Lights with high operating temperatures (due to small enclosures) burn out quickly.

Washrooms and toilets have lights that are on continuously. The type and placement of light fixtures varies considerably between different coaches. The most variability in lighting in European rail cars is in dining and lounge/club cars.

External light can be varied by closing shades or curtains. Some of the shades (for example in the DSB Lyntog) reduce the glare from the sun but are not opaque. All sleeping cars have opaque shades or curtains, however.

G. Signs

Pictographs are more common than written information on newer equipment in Europe. However the letters WC are generally used for the toilet, and the numbers 1 and 2 for first and second class cars or compartments. Pictographs indicate areas for smoking, no smoking, no dogs, washing, garbage, and dining.

On the more modern equipment there is an automatic sign indicating whether the WC is in use. This sign can be seen from the other end of the car so a passenger knows when the facilities are free. The latch that locks the toilet door from the inside controls the lighted sign.

Inside the washrooms and toilets instructions are presented with a mix of pictographs and words. The written signs are usually presented in two or more languages. There are additional signs and pictographs on things such as door handles and windows.

On newer German (DB) trains the sign indicating the direction of the dining or snack car can be transilluminated with either a forward or rearward arrow. On the RENFE Talgo in Spain, small plastic signs slip between horizontal channels. The direction of the arrow depends on which side of the sign is facing out.

In addition to directions and instructions, many trains also have some advertising. On longer distance trains, advertising generally relates to the rail company or to the attractions of some destination city. Product advertisements are more common on shorter distance trains.

H. Other visual stimuli

Most of the visual stimulation for passengers comes from other passengers and the scenery outside. Cars with couchettes, compartments or bedrooms limit the view of other passengers. The open coaches also have the best view of the scenery since you can see out of more windows at once.

Windows are usually fairly large, up to 140 cm long and 90 cm high. In most cases they are well aligned with the rows of seats. However in Some of the open Talgo coaches several rows of seats are not in line with windows.

Windows are usually tinted to reduce solar heat transmission in the Summer. Tinting is particularly common in air conditioned cars. Some of the more advanced tinting, such as in newer Amtrak (USA) coaches, reduces heat input but still has good colour rendering for sightseeing and picture taking.

I. Space

1. Public spaces

Passenger coaches, compartment cars and sleeping cars all have an aisle or corridor and some toilet/washroom facilities. There are shared showers on some first class German (DB) sleeping cars and in the new British Rail MK3 sleeper. The various rail companies recognize that there is a demand for more shower facilities on overnight trains. The need in Europe is answered to some extent by shower and bath facilities in train stations, but this is less convenient.

Many intercity and long distance trains have dining or snack bar cars of some sort. The space allocated varies from an entire car to a snack bar at one end of a seating car. In some dining cars the furniture can be removed or rearranged for special functions.

Several railways also have conference cars available on request. On Denmark's Lyntog, some of the compartments can be combined for conferences or meetings. There are a few cars in operation in Europe which have special play areas for children, but they are not widely used.

2. Accommodation spaces

The most modern seating cars are all of the open or saloon type. The Danish Lynto has retained some compartments in first class but these are also used as conference rooms. In some seating cars a glass partition and door separates the car into smoking and non-smoking sections.

Coaches having compartments for seating generally have six seats per compartment, although some second class compartments have seats for eight. There is usually some adjustability in the seats, although only some of the DB compartments have seats that fold all the way down.

Besides the sleeping spaces provided in some seating compartments, there are also couchettes and bedrooms. The standard European couchette seats and sleeps six. Many can be made up with only four beds, giving more headroom for someone sitting on the bed. First class bedrooms often have bunks on one side of the compartment. Either one, two or three bunks can be prepared, depending on need. Single accommodation is the most expensive.

There are bedrooms for two on T2 and T2S sleeping cars, and rooms for four on Talgo trains. The Talgo rooms have a diagonal orientation which permits more beds, a different arrangement of storage space and wide areas in parts of the corridor. The newest Amtrak equipment has double deck sleeping cars, with either sleeping on both levels or a kitchen and dining area on the lower level.

A sample of interior plans and dimensions is included in the appendix for some contemporary train designs.

II. BEHAVIOURAL VARIABLES

A. Boarding and leaving the train

Several European train stations have a sign or display indicating the composition of either specific or typical consists. This facilitates finding the right car, or the best place to wait on the platform for your train. Most trains require some change in level when boarding, and there is usually some gap between the steps and the platform.

Train crew can assist passengers in boarding or alighting, especially if such help is requested in advance. Most passengers have to board on their own or with help from friends. It is particularly difficult to board trains carrying luggage in both hands. Minor mishaps are relatively frequent during boarding and alighting trains in most countries. Although few rail companies plan to have level entries, several have special folding steps to assist passengers. There is a special wheelchair lift on the Lyntog, and several other rail companies provide narrower wheelchairs for use on board.

B. Locating your "territory" on the train

Bedrooms, couchettes and compartments are marked with seat numbers, as are seats in some of the newer saloon cars. On the TGV all seats are reserved and are marked overhead. In cars or trains where seats are not reserved they may still have seat numbers for use at other times on a reservation basis. There is usually a train crew member somewhere nearby during boarding to help passengers find their place.

C. Handling luggage

Handling, storing, monitoring and accessing luggage on trains can cause problems. Most rail companies have found that passengers are reluctant to leave their bags in racks in the vestibules. They want to be able to see their luggage. This problem has been solved by putting the luggage racks into the coach itself, or in the vestibule separated by a glass wall so that the bags can be seen from the seats.

Luggage racks over the seats also have their problems. They are either too high for short people or too low for the heads of tall people. This is less of a problem in compartments since the racks aren't directly above the place where a passenger would stand. In addition, it is easier for a passenger to stand on a seat to access the rack.

The ability to see luggage through the rack has had variable solutions. Some cars have slots, some have small holes, and some have glass shelves. Umbrellas, coat buttons and other items may get caught depending on the design. The Talgo coaches have a combination of slots and a grid screen which seems less likely to catch parts of baggage.

In the rooms and couchettes there is baggage storage under the seats, on racks and above the door. Sometimes access to some of these storage areas requires acrobatics. Small persons and those with physical handicaps can have serious problems trying to get a large bag on or off of a high luggage rack.

The problems are compounded since there are generally no enforced limits on the number of bags and parcels. Some large objects, such as bicycles and skis, can't be stored near your seat, however.

D. Activities in the accommodation space

1. Sitting

Seats on long distance trains are more spacious and comfortable than on shorter runs. First class seats are also usually roomier and more comfortable than those in second class. The seats in compartments usually have headrests and armrests. Some have wings on the headrests and some of the Trans Europe Express (TEE) trains also have small footstools. The seats and headrests are somewhat adjustable. In compartments, the headrest is often wedged between the two wings and can slide up or down.

On all-day intercity trains, most passengers spend the majority of their time sitting in their seats. In several design studies seats have been rated in terms of hours of comfort. Most typical journeys in Europe do not require sitting for periods longer than 6-8 hours. On the other hand, many overnight trains do not even have sitting coaches, but only bedrooms and couchettes.

2. Reclining

Once the beds are made in a room or couchette, it is hard to sit comfortably. Passengers often recline on their bunk to read or watch the scenery. Limited reclining is possible in most of the seats on the train, but most European trains do not have seats comparable to the large reclining ones with legrests found in some Canadian and US equipment.

3. Reading

Reading is a favourite pastime of many train passengers. It vies only with napping for the most common behaviour. The general light level is high enough for most people to be able to read easily. But people doing work, or those with some visual difficulties may require more light than is typically provided. In many European trains, the reading lights do not work unless the room lights are turned down.

4. Talking and social interactions

Trains in most countries are fairly friendly places. Passengers often get involved in conversations with strangers, especially if they are seated nearby or in the same compartment for a long trip. The exception may be when unacquainted males and females share a couchette on an overnight train. The females are more reluctant to engage in conversations with unknown males.

5. Playing games

The playing of games is rarely seen on most trains. Occasionally family members travelling together can be observed playing some game on a table. But most places on the train do not have a table large enough for board or card games. Railways do not provide games although some have cards or small items for entertaining children.

6. Sightseeing (looking out the window)

Attempts are made to keep the windows clean but they are not 100% successful, especially in the winter. The inside windows often have smudges and streaks, indicating infrequent or sloppy cleaning. The outside windows are usually cleaned by machine. In Sweden, this automatic washing equipment does not work well in very low temperatures. The French cleaning machines can work at temperatures down to -10 using an antifreeze solution. Outside cleaning of long distance cars usually takes place once or twice per week.

Spray from the wheels on the tracks causes most of the dirtying of outside windows. Some special TEE trains have more glass in the wall between the compartment and the corridor to improve the view.

7. Working

Many train travelers in Europe and Japan are businessmen travelling alone. The are likely to want to do some work on the train. The work generally consists of reading or writing, but dictaphones, calculators, and tape recorders may also be used. In special conference cars of some companies there are projectors and other equipment available. Some trains can also provide a secretary by arrangement. Many new trains, like the TGV, Lyntog, and Shinkansen, have telephones on board that can handle outgoing or incoming calls.

8. Self care (space required, preferred location, baggage access)

Space is quite limited on most trains, especially when they are carrying a full load of passengers. Rooms and compartments do not have enough space for two people to dress standing at the same time. It is generally not possible to spread your belongings out over a large area, except on your bed.

As mentioned above, most trains do not have showers. In addition to the few that have shared showers, some Amtrak Superliners have a private shower in the deluxe bedrooms. Minimal washing with a washcloth or water in the sink is possible in washrooms.

The tap water on European trains is not guaranteed to be suitable for drinking. Spanish and Swedish sleeping cars have bottles of drinking water in the rooms, and the Spanish trains even have small packages of toothpaste. Recently some German (DB) sleepers have been provided with small, sealed glasses of mineral water for rinsing teeth. Swedish coaches also have bottles of water and paper cups.

9. Care of travelling companions

Most newer trains have some area for child care, such as changing tables in one of the washrooms. Some also have facilities for the handicapped (eg. TGV and Lyntog.) On most trains a handicapped person's attendant travels on the same ticket.

10. Sleeping

Sleeping is quite a common behaviour on the train, but the conditions are often less than ideal. The lateral accelerations of the train are the most disturbing for the majority of passengers. Train stops, especially if they involve recoupling some of the cars or customs inspections, also disturb sleep.

The beds are too short for taller persons to be comfortable. Since some are only 177 cm long, anyone taller than that cannot stretch out without touching the ends. The Swedish sleeping cars are designed based on a wider clearance envelope, so their beds are somewhat longer, and could accommodate a larger proportion of the population comfortably.

There is some suggestion that the lateral accelerations are less bothersome in Talgo trains since the beds are diagonal to the direction of motion of the train. This has not been studied systematically, however.

11. Intimate social behaviours (both positive and negative)

In most countries, negative social behaviours such as fights are most common when many of the passengers are male sports fans. Other social problems are generally minor and involve such things as disagreements over temperature or light level, access to storage, or the behaviour of children or pets.

Some sexual behaviour may occur on the trains, but the beds are generally only about 66 cm wide. This is barely big enough for one stationary person. The rail companies report no problems in this area.

12. Smoking

Smoking is allowed in the smoking sections, and in the corridors and vestibules of some trains. Some countries still allow smoking in the dining areas but most have banned it. Pipes and cigars are also permitted in smoking areas, unless a fellow passenger objects strenously.

The number of smoking passengers has decreased in most countries over the last twenty years. In some cases, smokers book a place in a non-smoking section, then go to the smoking section or the corridor to smoke. Sometimes as few as 10% of the passengers reserve space in a smoking section. Ashtrays are provided in smoking sections, corridors and washrooms.

E. Transitions between accommodation space and public space

The most difficult transitions are into and out of an upper berth when there is no ladder. Getting out of a window seat in an open coach car can also be a problem if there is someone in the aisle seat. Armrests and seatbacks provide some assistance in getting out of the seat.

The doors between cars on new trains are all automatic. Some are operated by a tread activator, others by a push button or switch in the handle. Those with a switch in the handle can cause some problems when the door opens more quickly than the passenger can release his grip. The resulting banging of elbows led the SBB (Swiss) to redesign the handle so passengers couldn't put their fingers through it, but only push it to one side.

Doors to compartments slide to one side and are manually operated. Doors and latches on washrooms are also manual. Most toilet and washroom doors open inward. In some cases the door hits the toilet lid if it is left up.

There is sometimes a change of height going from one area or car to another. These are usually slopes, not steps. They are not marked and can cause some walking difficulties if they are unexpected.

F. Activities in common or public spaces

1. Aisles

There is little activity in the aisles on most open coaches, besides an occasional stretching person. The corridors in sleeping or compartment cars are more common hangouts. Passengers stand in the corridor, look out the window, and smoke or talk to other passengers. Many of the cars have fold-down seats in the corridors. These come in handy once the beds are made but before you're ready to lie down.

2. Washrooms, toilets

The washrooms and toilets on most European trains are small and cold, and therefore not conducive to lounging. In some of the newer systems (eg. Lyntog and TGV) the toilet can be operated while in the station, but the rest flush directly on to the track.

The Lyntog also has a special washroom for handicapped persons. It is next to a compartment for the handicapped and has a wide sliding door, special handrails and other adaptations. The handicapped washroom and compartment are at one end of the car with a wider corridor to accommodate wheelchairs.

3. Lounges, snack bars and restaurants

Many of the newer trainsets have a snack bar car or trolley service instead of a full dining car. Some offer either take away food or full meal service. Many use frozen meals and a microwave for speed and economy (unused meals can be kept frozen for another trip.) The Swiss seem to be the only ones who are still making full dining cars, and Sweden is currently testing a new Swiss dining car for winter serviceability. The Swiss also still make meals fresh on many routes.

Of course, many older dining cars are still in operation in several countries. The Amtrak Superliners are also equipped with a full kitchen. The trend, however, seems to be more toward prepared meals, limited choices, and snack bar or trolley service. The French offer some rather fancy food from their trolleys (eg. Canard a la mandarine with appetizer, dessert, cheese, etc.) The trolleys are specially designed (high and narrow) so that passengers can pass the trolley in the aisle.

G. General Psychological considerations

1. Regulation of human contact

Initially, the control of human contact depends on the choice of accommodation on the train. Those with adequate resources can get a private bedroom, or buy all the seats in a compartment, or even have a private coach. Most passengers, however, ride in first or second class accommodation in the near proximity of strangers. Use of aisles, vestibules, dining cars, and other public spaces on the train can entail contact with other strangers.

The general practice in Europe is to assign only men or only women to individual first class sleeping compartments. Previously, a couple travelling together would have to get a more expensive double room. The T2 and T2S cars were designed with double rooms so that couples could have a room together at a lower price.

The other alternative is to sleep in a couchette compartment. In couchettes both males and females are assigned to compartments. The expectation is that passengers will remain dressed while sleeping. Passengers expect to be sharing space with strangers and are generally cooperative in terms of respecting each other's personal space and belongings.

In the seats, the armrests and headrest wings serve not only as support but also to reduce physical contact between adjacent passengers. The compartments seating six or eight persons limit the social contacts to a small group. But row seating all facing the same direction - although in an open car - puts the passenger in physical proximity with fewer social stimuli, such as eye contacts. People differ in their preferences for physical and social proximity. Some prefer social isolation even if they are in close physical proximity. Others would rather have some social interactions with nearby fellow passengers, especially if the trip is long.

Having some social contact with nearby passengers has a beneficial side effect. If you have had some conversation with a passenger in the same row or compartment, you can feel more comfortable leaving your bags there to go to the washroom, dining car, etc.

Human contact is affected by the relative density of passengers and their activities. At peak times when the trains are full, it is hard to avoid some accidental contacts, especially at boarding and alighting times. At other times a passenger may be travelling alone in a compartment for six, without even another passenger to look at.

There is sometimes an opportunity for passengers to affect their social environment. Passengers wanting more or less social contact can reserve or choose a place that is conducive to their goal. For example, a single seat in a first class 2+1 coach is private while a seat at a table for four or in a compartment for six is not. In a few cases passengers may even be able to turn their seat to face towards or away from others. Examples of moveable seats in modern trains are found in new Swiss coaches and in many lounge and bar cars (eg. the large swivel chairs in Japan's Shinkansen lounge car.)

It is often hard to be alone anywhere on the train except the washroom. But washrooms are generally not designed to encourage people to spend long periods of time there.

2. Relation between perceived cost of furnishings and "comfort"

There are some efforts made to create luxurious interiors in modern public trains. Examples include extensive use of wood in Swedish sleepers, tooled leather wall panels in Spanish Talgo trains, and velour seat covers in TEE trains.

However, the large national passenger railways are not as luxurious as some trains of the past, or some private railways such as the present tourist version of the Orient Express. The railway for the white population of South Africa is perhaps the most luxurious national railway, but it cannot be considered to be "public" in terms of its passengers.

Restaurant-style service (cloth table covers, silver utensils, many choices on the menu) is another feature which adds to the cost but increases passengers' comfort and satisfaction.

3. Relation between perceived cleanliness and "comfort"

Cleanliness is important in all areas of the train. The main cleanliness issues for passengers are;

- clean and sanitary washrooms/toilets
- clean seats and floors
- clear windows and
- clean eating facilities.

Many railways (such as the DB in West Germany) have a cleaning person who rides on some portions of long journeys to clean washrooms and empty garbage from containers in passenger areas. For shorter trips the train may only be cleaned at the end of the journey.

4. Perceived and actual safety

Modern trains are correctly perceived to be quite safe. The biggest safety problem in most countries is autos or trucks at level crossings. Most minor mishaps occur while boarding or leaving the train. The AAR in North America and the UIC in Europe have specified standards for safety features such as fire retardancy of materials, structural integrity of cars in accidents, emergency escapes, etc. All trains are equipped with some sort of first-aid equipment and staff generally receive some first-aid training.

5. Phobias, fears

In most cases, special fears or phobias can be alleviated with some assistance from train personnel. This may require special seating near an exit, reassurance during a trip, or help in resolving some social conflict between passengers.

One interesting instance of dealing with fear on the part of the passengers is the speed display on Denmark's Lyntog train. The train speed is indicated on a lighted display with the time. The driving crew may wish to increase the speed beyond the nominal 125 km/hr limit of the train to catch up to schedule. Because this might worry the passengers, the display has been electronically fixed so that 125 is the maximum speed displayed even though the train may be going faster! The display indicates the correct speed below 125 km/hr.

6. Stress reduction

Many activities can be stress reducing, depending on the individual and the stressors. Trains are designed to produce as little stress as possible, but there are few features designed specifically to reduce stress.

Many modern trains serve alcoholic drinks, but not all of them do. West German sleeping cars are run by the same company that does the catering and the staff member in each car has a supply of food and drinks for sale. Swedish sleeping cars, on the other hand, have less than one staff member per car. There is no food or drink service, and consequently lower fare supplements. In the Swedish dining or lounge cars, alcoholic drinks are only served with food, but in practice this can be as little as a bag of peanuts.

In most respects, passengers are left to their own devices for finding ways to avoid or reduce stress. One feature mentioned previously that would reduce stress is more information concerning delays, their cause, and their expected resolution.

7. Entertainment, festivities

Many rail companies have special cars that can be included in a train consist for a special party. Rail personnel often use these cars for meetings, press conferences, family weddings and the like. For example, DB in West Germany will include a special lounge/party car for the price of 20 tickets plus delivery of the coach to the departure station. This sort of arrangement must be made several weeks in advance. Other railroads also have party/disco cars, special conference cars, etc. Often one car has moveable furniture, sound systems, etc. so that it could serve many special purposes.

On ordinary trains passengers may have their own celebrations, parties or entertainment in their own compartment or seating area or in a dining/lounge car.

On some of the TEE trains, such as the Rheingold from Amsterdam to Basel, local tourist bureaus provide entertainment and samples of local wines and foods for the passengers. This provides the community with tourist advertising and the passengers with some diversion, entertainment, and local history.

There is often some small item for children, such as souvenir tickets, comic books, or cardboard toys. Entertainment for adults is usually limited to the availability of playing cards on some trains.

8. Special travel groups

Special travel groups can be accommodated by most railroads if arrangements are made in advance. An outstanding example of this is SNCF's special services to pilgrims to Lourdes. The SNCF meets annually with doctors and priests who operate the pilgrimages for planning. Since many of the pilgrims have severe infirmities or disabilities, they use special ambulance cars with equipment such as beds, stretcher access, oxygen apparatus, etc. And they contact hospitals along the way before the trip to define any emergency procedures that may be required. For many of the pilgrims, it is their only trip of the year and it has special significance. The extra efforts to accommodate this special travel group are certainly appreciated by the passengers.

9. Travelling with pets, valuable livestock, etc.

In many European trains it is possible to take your dog in the passenger compartment if you buy a child's (half price) ticket. The dog is not allowed on the seat, however. Dogs are not allowed in some compartments on these trains. This may mean four types of compartment -

no dogs, no smoking
no dogs, smoking
dogs, no smoking and
dogs, smoking.

On most trains, small pets are allowed if they are in a cage that fits under the seat. Birds, turtles, cats and small dogs can travel in this manner. Larger animals and livestock travel in baggage cars. In the Danish Lyntog, the handicapped compartment is also hypoallergenic - that is, no smoking, no pets, and no wool carpets.

III. INTERACTIONS WITH RAIL PERSONNEL

A. Identifying help, information, or authority figures

The train personnel wear some indication of their status as staff, but it is not always obvious to the naive passenger. When the crew member isn't wearing a hat, the only indication may be the jacket colour or the insignia on a necktie.

B. Training and demeanor of staff

Staff on railroads are trained in public relations and first-aid, as well as in their specific duties onboard. On European trains, many crew members speak more than one language, and try to be helpful even if there is a language barrier. Crew members give special help to handicapped persons or others needing help if they receive a request in advance.

C. Emergency management

Emergencies are, fortunately, rare on modern train journeys. There are emergency brake handles in all compartments and coaches, and first-aid kits in all cars.

Staff are trained in emergency management, and provide first-aid in emergencies. The trains can radio ahead for other assistance at the next stop when necessary.

B. CURRENT AIRLINE PRACTICE

I. GENERAL ENVIRONMENTAL VARIABLES

A. Temperature

On most airlines the temperature varies depending on the route, flight time, and passenger feedback. There are no major differences in heating requirements in summer vs winter, since the outside temperature at high altitude doesn't vary appreciably.

However, the passengers' clothing and prior adaptation may vary with the season or climate. Temperatures are maintained fairly high (around 24 degrees C at the sensors near the air outlet.) The temperature near a particular passenger varies with the passenger density, and proximity to the window. The high air supply temperature is offset by good air circulation.

However, the temperature can also be modified to suit passenger comfort by asking the flight attendant. The temperature can be adjusted independently for different zones of most modern, large airplanes. If there is a conflict concerning the temperature within a zone, the colder person can be provided with a blanket.

Air conditioning systems for ground time serve mainly to remove excess humidity. Maintaining humidity is important in flight since the fresh air coming in is very dry (due to the low temperature.)

B. Air quality

In addition to removing or maintaining humidity, there are several other air quality issues. Individual fresh air jets are provided on many planes (eg. 747's) while others have zone ventilation. The air is changed up to 20 times per hour to maintain freshness. No windows open except for a small one in the cockpit.

Air flow rates in cubic feet per minutes per passenger are deemed optimal at 20 and sufficient at 14. In cases where individual air jets are provided, their rate and direction can be controlled by the passenger (if they can reach them).

Due to the high altitude at which these planes fly and the need for fresh air intake, ozone levels can become too high. Ozone filters are required to reduce the amount to acceptable levels.

C. Auditory stimuli

Air passengers are sometimes bothered by "strange" noises such as changes in engine thrust, landing gear noises, lightning, hailstorms, etc. There is never too little noise since there is always an ambient noise on aircraft. This noise comes from air conditioning and ventilation, the engines and auxiliary equipment, and other occupants.

D. Vibration

No problems arise from vibrations on most large airplanes except bouncing of the plane when braking or taking off. The level of vibration in flight is not sufficient to interfere with reading, writing, or other passenger activities. Usually it is not even detectable by the passengers. Vibration is more of a problem on smaller aircraft (such as some prop-jet commuter plans).

E. Accelerations

Passengers are always sitting when the plane is accelerating on take-off and landing. Even so, this movement is often bothersome, particularly for people who are anxious about flying. If a passenger is in the washroom when the plane is accelerating, there are handholds for balance.

There may be other accelerations, due to the plane's banking or changing altitude, or due to turbulence. If these are anticipated, the public address system is used to notify passengers to return to the their seats, and the seat belt signs are turned on. If they are unanticipated, passengers who are standing or walking may lose their balance. The seats generally don't have handholds for passengers in the aisle, but the luggage rack may be graspable. The interior is designed with no sharp edges, so that injuries to falling passengers will be minimized.

The airlines claim to place safety first, comfort second, and schedule third. Consequently they try to avoid any maneuvers or situations where excessive accelerations would compromise safety or passenger comfort. Despite these precautions there are occasional flights where serious injuries do occur due to air turbulence or "air pockets".

F. Lighting

On most commercial planes there are individual passenger reading lights, overhead cabin lighting, and emergency lighting. On many craft there are lights behind the luggage rack which illuminate the side wall. Light levels for the main lights are controlled by rheostat. The cabin lighting is set at different levels for day and overnight travel. The cabin lighting is also turned down during in-flight entertainment such as movies. During movies or sleeping times on overnight trips, enough light is maintained to permit passengers to walk down the aisle safely. (However, this level may not be adequate for people who have specific visual problems in low illumination.)

The emergency lighting is kept on all the time. It indicates the exists and washrooms, as well as providing some cabin illumination. The individual reading lights are controlled by a switch at the passenger's seat. They can be operated independently regardless of the level of the other lighting.

Light from the outside can be reduced by closing the pull-down shade on each window.

G. Signs

Airplanes have the following types of signs on board: exits, emergency exits, smoking, no smoking, passenger seat belts, call button, seat locations, and washroom. There is an emergency sign in each of the washrooms that can be activated to tell passengers to "Return to the Cabin."

Information is also presented by audio announcements, live and videotape safety demonstrations, and a seatback safety folder in multiple languages. Most major airlines also provide their own magazine on-board, which often gives information about the airline or its routes as well as general interest articles. These magazines have advertisements which offset production costs.

H. Other visual stimuli

Airline interiors are generally light and bright. The walls and ceiling are usually covered with some white or cream coloured flame resistant vinyl wall covering. Seats are typically covered in some colourful patterned material of wool and synthetic blend fabric.

Besides the interior of the plane, visual stimulation also comes from the flight attendants, the other passengers, and the windows. The windows are generally small and placed below eye level for most passengers. They are small because of strength requirements, and below eye level because most of the scenery is below. The windows on a typical craft (DC-10) are 11 inches wide x 16 inches high. They are lined up with the seats and have a 20 inch wall space between adjacent windows. The windows are clear except for those in the exit doors which are tinted.

I. Space

1. Public spaces

The public space on an aircraft usually consists of aisles and, in a sense, washrooms. On some larger planes, such as the bi-level 747, there may also be a lounge area, or even a piano bar. The floor in the aisle and seating area is covered with fire resistant carpeting. Linoleum is used in the galley area and the washrooms.

2. Accommodation spaces

The number of passenger seats on the main commercial planes varies from 99 to 456. Up to 17 crew members are also accommodated on the largest planes (747s). All passenger seats have a headrest, armrests, and a footrest. Some international long distance planes have wider seats than domestic planes. However, these wider seats are often only found in first class at a substantially higher price.

First class airline passengers have more space, more and better food, more service from the flight attendants, and other occasional extras, such as fresh flowers or free newspapers from the destination city.

On some long distance overnight flights, a few airlines offer sleeping accommodations. This type of accommodation is quite expensive, since it takes up the space of two or more first class seats.

II. BEHAVIOURAL VARIABLES

A. Boarding and leaving the plane

Passengers who need some assistance boarding and alighting are usually assisted by flight attendants. An announcement in the departure lounge requests those with children or other space needs to board first. Upon arrival, those passengers who need assistance generally have to wait until the other passengers have deplaned.

Boarding and alighting used to require climbing up and down metal stairs pushed up to the plane. In most large airports the major airlines now have covered entranceways that allow the passengers to enter and leave the plane with a flat or gently sloping ramp. This also protects the passengers from extremes of outside weather.

Passengers checking in at the airport with a valid ticket and reservation are issued a boarding pass. The flight attendant at the door checks all of the boarding passes and removes the ticket, to insure that only authorized passengers enter the plane.

Many planes have special wheelchairs for boarding and alighting of non-ambulatory passengers. Other passengers have been put on long flights carried on a stretcher, or even in an iron lung. Accommodating these passengers requires temporary removal of seats from the craft.

B. Locating your "territory" on the plane

In most cases seats are assigned to the passengers when they are issued a boarding pass at the airport check-in. But some U.S. lines issue seat assignments when you buy your ticket. On some shorter commuter flights you can choose an empty seat and buy your ticket on board.

But generally, the passenger enters the plane with an assigned seat. The flight attendant can direct passengers to their seats, if help is needed. The seat numbers are usually displayed over the row of seats.

Boarding and alighting times are usually crowded and uncomfortable, primarily because of the small aisles and the overhead luggage bins. The seat spacing is not conducive to easy access. The person sitting on the aisle has to stand up or even move into the aisle to let someone get to the centre or window seat.

C. Handling luggage

According to the stated restrictions of most airlines, passengers are allowed on board with one piece of luggage that fits under the seat. It can have maximum dimensions of about 20"x 6"x 13". Garment bags that are hung up can be longer. A purse and/or camera may also be carried on board.

The flight attendants can help passengers put some of their luggage in overhead racks. These racks or bins have a door and latch and can hold up to 140 lbs each. There is usually one bin for every 2 to 4 seats. The bins are most commonly used for coats and hats. They may also house pillows and blankets. There are no overhead bins in the upper deck of 747s, however. Most large planes also have one or more closets for garments bags. Some wide-bodied planes have spacious "dumb-waiter" closets.

In addition the passengers can check two pieces to the destination not to exceed 70 pounds each. The overall dimensions of the checked bags are also subject to some restrictions. Some objects, such as skis and musical instruments, cause problems when passengers want to carry them on the plane. Fresh foods are a customs problem. Wheelchairs are loaded underneath in the luggage compartment but batteries must be drained first.

Some unusual "baggage" is also problematic. For one Canadian charter airline this has included such things as an engine block, an entire car (a Rolls Royce), large amounts of band equipment including pianos and speaker towers, and trophy specimens from hunting and fishing trips.

In some countries with more lenient carry-on rules, passengers have been known to carry microwave ovens or small refrigerators on their laps, or pile them up in the aisles, for journeys home from a duty-free port.

D. Activities in the accommodation space

1. Sitting

Regardless of the duration of a flight, most passengers will spend the great majority of their time sitting. Getting up and walking around isn't encouraged on airplanes. In fact, it is often suggested in the announcements that passengers remain seated with their seat belts fastened. An air pocket, like rough track, is not noticed till you hit it.

The seats vary depending on the accommodation. Sample dimensions for a Wardair 747 are contained in the following table (all dimensions in inches):

seat height (front)	18
seat height (rear)	16
seat width	17.5
cushion height	5
seat depth	19.5
backrest height	26
backrest width	19
side armrests	2
centre armrest	4
pitch	34
aisle width	20

The seat dimensions in "first class" are usually more generous. However, they are still not wide enough to accommodate all potential passengers. Very large or obese passengers may require two seats. The centre armrest can be raised in some seats to give more space.

2. Reclining

Airline seats usually recline, and most passengers take advantage of this feature on long flights. The airlines require the seats to be upright during take-off and landing, however. The degree of reclining is limited by the seat pitch and the food tray that it often on the back of the seat. To recline, some coordination with the passenger behind is necessary, especially if the tray is full of food and drinks. The reclining mechanism is generally an unlabeled button on the armrest.

3. Reading

All major airlines have reading materials for use by passengers. In addition, many passengers bring their own reading material. Reading is a popular activity on long distance flights. Reading lights are focused to cover a limited area in front of the passenger. Their adjustability is not often adequate for the large varieties of body positions that passengers adopt when reading. Some do not have any arm adjustment and others only move in one axis (left-right.) The adjustments often require getting up from the seat for all bu the tallest persons. This situation often pits optimal lighting against optimal physical comfort for people who read on long flights.

Reading can serve as a form of privacy regulation on airline flights and other situations of forced proximity to strangers. The seats reservation may have placed you beside someone with whom you don't wish to converse. Although you have no other accommodation to go to for the length of the trip, if you are always reading intently or sleeping the adjacent person probably won't interrupt too much.

4. Talking and social interactions

Most talking on the airplane is with the flight attendants and the person(s) next to you. Talking with the person across the aisle is fairly rare. Even talking to the adjacent person is not frequent unless you already know them. Passengers on charter or vacation flights are often more sociable.

5. Playing games, entertainment

Some planes have music and films. There may be an additional charge for the use of the headset. Music is provided on a number of different channels, each with its own format (eg comedy, classical, country and western, pop). The music is from a multitrack tape and a program is provided in the airline magazine. On a long flight the programs repeat.

On long international flights the passenger headsets are different, the magazines are different, and promotional items are offered. Many airlines provide playing cards or children's materials such as crayons and colouring books, on request. Some airlines allow you to eavesdrop on air traffic control information and to watch take-off and landing on a video screen.

Passengers may also bring their own games, radios, etc. On some airlines, computers and computer games are not allowed to be used in-flight. On others their use is only restricted during take-off and landing. Some airlines are themselves providing video games that fit into the food tray.

6. Sightseeing (looking out the window)

The windows are not tinted but there are shades on them. Windows are cleaned by hand. Very few conflicts arise from changing a light, vent, or window shade that also affects other passengers. The window shades are usually up but windows and sightseeing are not a prominent aspect of commercial air travel. Some pilots provide a nice touch when they announce special features of the geography, such as the Grand Canyon, but the view from miles above is often less than expected.

7. Working

Working on airplanes generally consists of reading reports or other work related material. Some passengers may also write, knit, listen to cassettes, or engage in crafts. The resolution of present questions concerning use of personal computers on commercial airlines may open up new avenues for work during long flights.

8. Self care (space required, preferred location, baggage access)

Many airlines do not seat pregnant women or handicapped persons near emergency exits. Although most planes do not accommodate full size wheelchairs, the airlines may provide a smaller wheelchair for boarding the plane or movement on board, such as going to the washroom. The seating area is rather cramped for self-care activities. It is difficult to put on or remove your jacket or brush you hair without impinging on the space of the adjacent passenger.

Consequently, most self-care is performed in the washroom. The washrooms provide winks, toilets, soap, paper towels, facial and toilet tissues, mirrors, an outlet for an electric razor, and, in some cases, other amenities such as hand cream, sanitary napkins, etc.

9. Care of travelling companions

Parents with infants usually sit in the non-smoking area. At some bulkhead seats special tables or small cots can be provided for infants. Games, toys, and puzzles are available to keep children occupied. Children's diets are also provided.

Wheelchairs are accommodated on some flights, but it is important that management be given advance notice. The 747's can handle 18 handicapped persons. The main consideration is whether the disabled person needs accompaniment. However, attendants are provided to assist disabled persons with eating and getting to the toilet.

10. Sleeping

On most planes the seats recline for sleeping and blankets and pillows are provided. The number of passengers who fall asleep depends on the length of the trip. However, sleeping is encouraged on overnight trips. There are no special sleeping areas on most long flights, however some airlines do offer sleeping accommodation for a few passengers. Others have wide reclining seats with leg rests in first class. Some passengers can be disrupted by others (e.g., noisy drunks) and judgment is used by the flight attendant in quieting them.

11. Intimate social behaviours (both positive and negative)

Airline personnel are sometimes required to intervene in conflicts between passengers. Fights are not common, however plainclothes security personnel may be put onboard for special groups such as sports fans. Only the washrooms offer any sort of privacy on an airliner, so whatever intimate behaviour occurs that requires privacy takes place there. Cultural differences may determine many of the constraints on social or parental behaviours during a trip (eg. nursing an infant or teenagers necking.)

12. Smoking

Smoking is allowed on most flights, but pipes and cigars are not allowed. About 20-60% of the seats are reserved for non-smokers. Several airlines report that there are fewer smokers on flights now than several years ago. Every seat usually has an ashtray.

E. Transitions between accommodation space and public space

The seat and aisle spacing is such that you are likely to run into someone if you need to get out of your seat to go to the washrooms. If you have a window seat you first have to alert the passenger next to you, then try to stand up without hitting your head on the luggage bin. Most passengers push up off of the armrests, grab the back of the seat in front, or both.

F. Activities in common or public spaces

1. Aisles

Walking down the aisles can be a problem is there is a bar cart in the way. There is also not much room in the aisle of most planes, so that you can bump into someone if their arms or legs are hanging out into the aisle, especially if you are carrying a bag.

2. Washrooms, toilets

Toilet facilities do not differ on day versus overnight trips. There is no problem with sanitary conditions being maintained over the course of a long trip because the toilets have a large capacity; flights are a maximum of 14 hours before there is a stopover. In addition, the flight attendants check the washrooms about every hour on most long commercial or charter flights. If there is some mess, they clean it up. Improper use of the washroom can include smoking tobacco, using other drugs, or sexual activities. There are two types of toilet controls on CP aircraft, depending on the type of plane: push button or handle (mainly).

3. Lounges, snack bars and restaurants

On most flights passengers get tray service the timing of which depends on the originating area of flight. Food service is thus scheduled from the departure or origin point. Meals are then scheduled according to the time of day, local time. Passengers are fed approximately once every four hours, sometimes twice. Special foods are no problem but they require 24 hours advance notice, expect for baby bottles which can be heated on demand. Only about 1-2% of passengers on most flights request special meals, usually vegetarian or kosher, but on some flights the proportion is higher. A few extra meals are usually included (eg. 310 for 300 passengers) and the flight crew must each have a different meal to reduce the possibility of more than one having food poisoning.

G. General Psychological considerations

There are seldom mishaps on most air flights. However, air sickness is not uncommon, affecting 1-5% of passengers depending on the roughness of the flight. On 747s there are sometimes mishaps on the narrow circular stairs between the upper and lower decks. Excess alcohol intake and high heels are both related to these falls.

On most planes seeing-eye dogs are allowed in the cabin. There is also a kennel in the cargo area.

III. Interactions with airline personnel

Airline personnel receive extensive training and are well known for their attentiveness and attractiveness. They wear distinctive uniforms and passengers believe that they can be called to your seat with the mere push or pull of a switch on the armrest or overhead.

They are trained in emergency evacuation and medical procedures. They demonstrate many of the safety features and routines at the beginning of each flight. However, this latter function is being taken over by video shows in the cabins.

C. CURRENT CRUISESHIP PRACTICES

To obtain information for cruiseship practices we contacted designers, travel agents and various cruise lines. The discussion will deal with both the specifics of various lines and certain common features.

I. GENERAL ENVIRONMENTAL VARIABLES

** Air conditioning in cruise vessels provides better air quality for the passengers. In refurbished ships air conditioning is often a priority.

** The constant background of a quiet engine or the rhythm of a railroad track are not noises the passengers will complain about. According to the designer we spoke to, they will complain about any intermittent noise within minutes of being onboard. Good design (structural components), the developments of acoustical materials, and new construction techniques eliminate a good deal of intermittent noise.

** Seasickness is often experienced when the ship has not been stabilized. Most of the larger cruise ships have been stabilized and so passengers do not experience the movement that they would experience in a smaller ship.

** The public is travelling more and more every year and their level of expectation of decor is very high. One designer suggests that the use of primary colours are fine, however, using too much contrast makes the eye "jump" and so is unadvisable.

Space

It is important for passengers to have the impression that their personal space onboard the ship is not constricted. The designer for Carnival Cruise Lines indicates that, with the introduction of "sunset" pastel colours into the decor of their cruise ships the impression of space is accentuated.

Accommodation spaces

A cruise ship differs from a passenger ship in that within a short period of time the ship returns to the same port of departure. One of the designers we contacted suggested that, "today's passenger expects the cruise ship to look and operate like a FIRST CLASS HOTEL!"

There is often a variation of accommodation found aboard the various cruise ships. Included on one of the ocean liners belonging to the Holland America Fleet are:

* the Staterooms Deluxe,
* the Deluxe Outside Double Rooms,

* the Large Outside and Inside Double Rooms,
* the Outside Double Rooms, and
* the Inside Double Rooms.

The Staterooms Deluxe

This is the largest and most luxurious accommodation onboard. There is a spacious living room area with picture windows. The stateroom also includes a kingsize bed, twin dressers and wardrobes, and a lighted makeup table. The large bathroom area includes a shower and bath.

Deluxe Outside and Double Rooms

This accommodation offers a queen-size or twin beds, a spacious sitting area, picture windows, dual dressers and wardrobes, lighted makeup table, large bathroom with shower and bath.

Large Outside and Inside Double Rooms

Spacious and comfortable with queen-size or twin beds. Many staterooms also have upper berths. Also, a large dresser, dual wardrobes, lighted make-up table, and a bathroom with shower can be found in this accommodation.

Outside Double Rooms

A stateroom studio with twin beds, a large dresser, dual wardrobes, lighted make-up table and a bathroom with a shower.

Inside Double Rooms

A spacious room with lower beds, a large dresser and wardrobe, lighted make-up table, and a bathroom with a shower.

Aboard the Norwegian Caribbean Lines accommodations include:

* the Grand Deluxe suites
* the Penthouse Suites
* Junior Suites
* Deluxe Outside Rooms
* Outside Rooms
* Inside Rooms

Sleeping accommodations can be "adjusted" to accommodate passenger requirements. A double bed, twin beds (two lower beds), lower berths, upper berths and folding upper berths are among the choices for the possible combinations. All rooms have a private bath and/or shower.

Aboard the Scandinavian World Cruises ships, all staterooms have twin or double bed capacity. All suites have queen size beds. It is also possible to have single occupancy for selected staterooms on one-and one-half times the rate listed.

A wide selection of outside and inside staterooms are provided aboard the Princess Cruises. A choice of double bed with upper pullman, double bed, twin bed, recessing lower bed, sofa convertible to bed, and sofa convertible to double bed is available.

Each of the staterooms has a private bathroom and shower, a telephone, a multi-channel music system, individually controlled air conditioning, 110-volt 60-cycle alternating current (A.C.) with standard U.S. plug fittings, and wall to wall carpeting. Deluxe suites are also available. These rooms might include a separate sitting room, a tub bath and a refrigerator.

II. BEHAVIOURAL VARIABLES

** Having elevators, as well as stairs, make the larger cruise ships very accessible.

** Although it is possible to read in the staterooms, onboard some of the cruise ships there is a library-writing room.

** Among the number of games that passengers can enjoy playing onboard various cruise ships are backgammon, bingo, shuffleboard, and table tennis.

Sightseeing

The Princess Cruises assure that scenery-gazing is possible through their floor-to-ceiling windows and spacious observation decks. Aboard their Transcanal voyage passengers stand on a large observation deck and watch the ship - nearly 20,000 tons - raised and then lowered 85 feet. Although the Sun Dome on the Observation deck can be closed if necessary, it is normally open or partially open.

Working

Although it is possible to do work in the staterooms, some cruise ships provide a library-writing room for their passengers. Modern, high-stability radiotelephone systems aboard cruises ships permit connections with telephones ashore. It is also possible to send out telegrams world-wide from the ships.

Self care

To help passengers look after their personal grooming needs most of the cruise ships provide electrical outlets with a current of 110 volts A.C., sufficient for electric razors, toothbrushes, and handheld hair dryers.

Most of the larger cruise ships also provide such amenities as a barber shop, a beauty salon, massage and sauna rooms, pressing and laundry services, and a gym.

A private bathroom and/or shower is provided in each of the staterooms aboard the cruiseships. There are also toilets next to major attractions (the dining room, the lounge/dance floor, the clubs, the gym, the casino) and showers next to the pools.

Lounges and Eateries

There are no class distinctions for the dining facilities of passengers. At the time of booking it is important to make dining room reservations onboard some of the larger cruiseship vessels. There are two sittings for the Breakfast, Luncheon and Dinner periods. The passenger is not limited to these three meals, as he can also enjoy a continental breakfast, a mid-morning bouillon, afternoon tea, and the gala midnight buffet onboard some particular cruise liners. It is possible to dine a minimum of five times a day onboard a number of the cruise ships!

Often there is French, Spanish, Italian and (North) American cuisine prepared onboard. A different cuisine is prepared every night. Soft chimes call the passengers to the dining rooms where they are greeted by the Maitre d'. Every attempt is made by the staff to honour requests for seating arrangements as specified with the travel agent. China, a silver place setting and linen table cloths are used on the tables. If special diets are required for medical reasons, arrangements must be made two weeks prior to sailing so that the cruise liner can cater to these requests. Having one/two pantries located on each of the decks where the cabins are located makes it possible to service those passengers who wish to stay in their staterooms to have their meals.

For some of the smaller sailing cruise ships dining is more informal - passengers are expected to put on their shirts! It may consist of pastries and coffee for early risers, breakfast, a lunch buffet or beach picnic, family-style dinner and late-night buffet. Morning Bloody Marys, afternoon rum swizzlers and dinner wine are sometimes a part of the one-the-house liquor service. Often the smaller sailing vessels cannot accommodate special diets due to the limited shipboard facilities.

General Psychological considerations

Flame retardant nylons, especially recommended for use in the Tropics, is the ideal upholstery to provide cleanliness as well as comfort. The designer for Carnival Cruise Lines suggests that the design possibilities and the flexibility make it comparable in status potential to wool.

Cleanliness is enhanced through the use of good design and specification of easy to maintain materials. One designer feel that the use of muddy colours and dull surroundings encourages sloppiness and does nothing to "hide" the dirt.

Perceived and actual safety

Ship designers are very conscious that passengers need to perceive safety as well as to actually be safe when they are travelling on the water. Often designers strive to make the safety features visible. For instance, the fire extinguishers, life rafts and preservers, depth indicators, radar, and radio telephones are some features evident to travelers.

Medical Centres provide passengers with a greater sense of security. There are a qualified physician and a nurse onboard the large cruise ships. (In fact, the size of the passenger cohort taken on freighters is defined by the maximum number which can be carried without needing to bring a physician along too.) The hours of service are posted, although medical attention is available around the clock. All medical services are charged to the passengers.

Because of the historic association of risk of fire on ships, continuing care is shown today. For example, ironing in the staterooms is strictly prohibited on some otherwise fire-safe ships.

The designer for Carnival Cruise Lines has claimed that the recent introduction of "sunset" pastel colours in the decor has created a very soothing atmosphere. One can argue that "colour" may be a factor in reducing stress.

As another means of reducing stress saunas and massage services are available onboard some of the larger cruise ships.

Entertainment, festivities

All passengers onboard the cruise ships enjoy the same entertainment. There is no class distinction made.

Among the festivities, the Scandinavian World Cruises vessels provides passengers with the "Captain's Cocktail Party." In addition, they help their passengers celebrate a birthday, an anniversary and other special events if their travel agent has been advised at least two week prior to sailing. The passengers can spend their leisure time at the various bars, night clubs, lounges, and pubs. They may also wish to visit the casino, the cafe, the shops, the disco, and the pool. A children's recreation area is also provided onboard the Scandinavian World Cruises ships.

Aboard the Princess Cruise ships the passengers can enjoy Broadway-style shows, a cabaret, a full-piece orchestra to dance to, a disco, a casino, and the bars. During the daylight hours there is swimming in the pool, games, movies, lectures on photography, a golf and cooking, trapshooting, disco classes, exercise classes, jogging, and visiting the duty-free boutique/gift shop. Often there are at least two formal scheduled events for the passengers to enjoy.

For the smaller sailing vessels often there is no social director. Passengers are encouraged to do what interests them including: help the mate hoist the sales, knot tying, soaking up the sun, singing, and dancing.

Special travel groups

Women who are more than 28 weeks pregnant and children under 12 months are not accepted as passengers on some of the larger cruise ships. For the smaller sailing vessels, children under 16 must be accompanied by an adult and there can be no children under seven onboard.

Although wheelchair accommodations are provided onboard some of the larger cruise vessels, often the structural design poses a problem. It is necessary for passengers who need wheelchairs to make their own arrangements prior to the cruise, as the number of wheelchairs onboard is limited to use for onboard injuries and acute requirements.

Baggage

On a space-available reserved basis the Scandinavian World Cruise vessels permit one passenger-type automobile (per cabin assignment) to be brought onboard free as part of the baggage allowance.

Often the larger cruise ships do not accommodate pets.

III. INTERACTIONS WITH CRUISESHIP PERSONNEL

Aboard each of the larger cruise ships the staff is quite large including: the deck stewards, the ship's officers, the chefs, the cruise director and his staff, the dance combo, the room stewards, and the Maitre d' and the dining staff. With one staff member for every two passengers, the Princess Cruise ships boast about their ability to serve their passengers. Each of the cruiseship personnel can be visually identified based on the uniforms they wear.

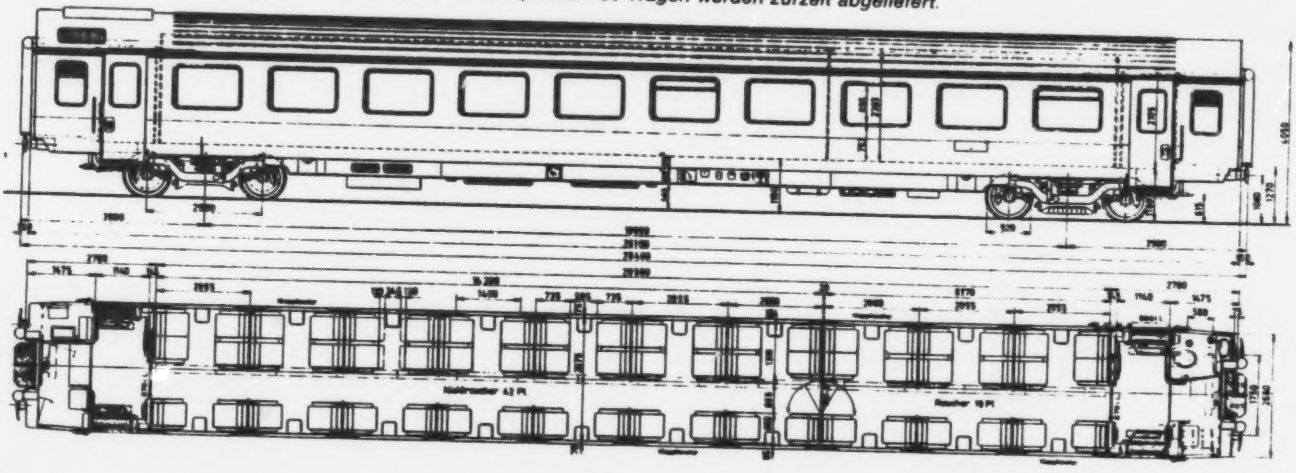
** Some cruise ships provide passengers with tour AV presentations using words, slides and movies, about the history and culture of each of the destinations to be visited. ("Next stop, Oba, Ontario...")

** Aboard the Scandinavian World Cruises vessels, ships' officers are responsible for directing the passengers with automobiles on and off the vessel.

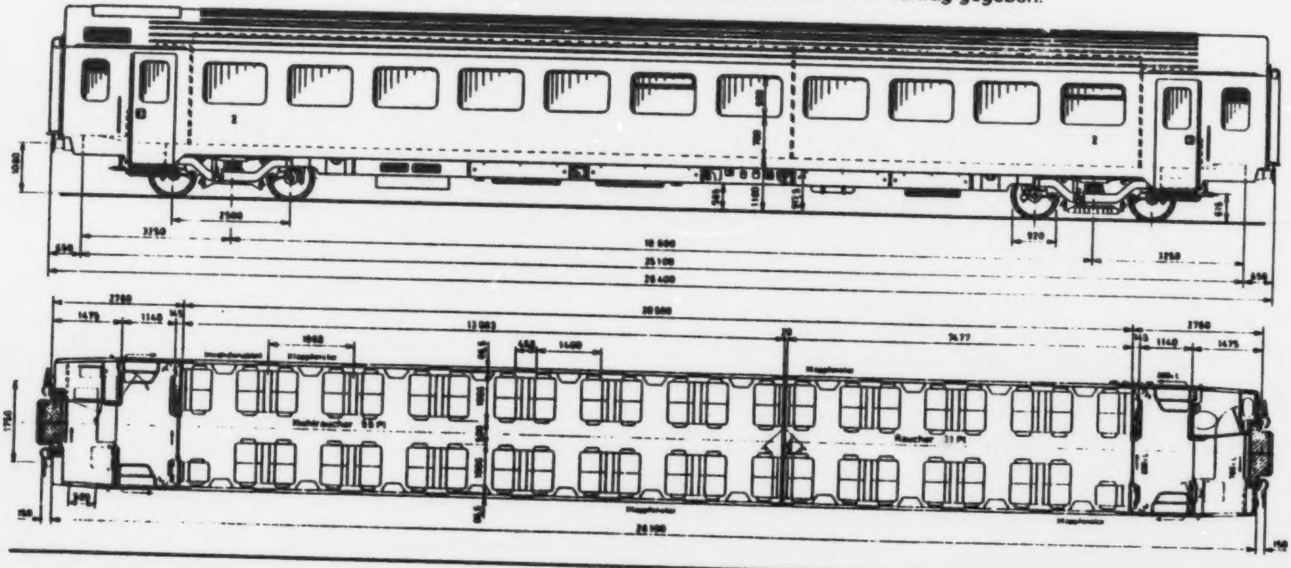
Current designs

SWITZERLAND

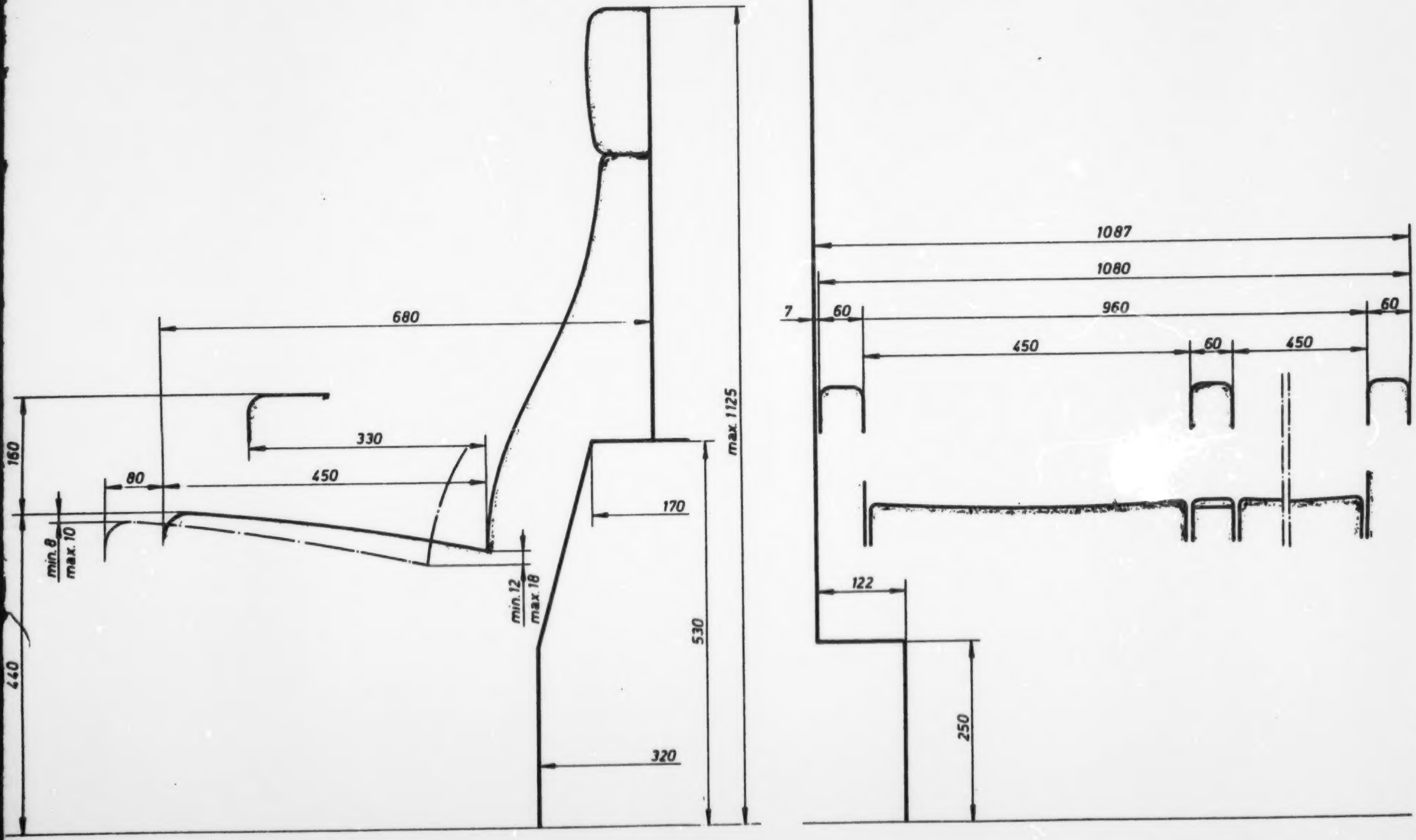
Typenskizze des Einheitswagens IV 1. Klasse mit 60 Sitzplätzen. 80 Wagen werden zurzeit abgeliefert.


2700
2500
920
25100
26400
2760
1475
1140
1400
Nichtraucher 42 Pl
Raucher 18 Pl
1270
1750
2840

Typenskizze des Einheitswagens IV 2. Klasse mit 86 Sitzplätzen. 60 Wagen wurden soeben in Auftrag gegeben.


2100
1160
3750
2500
920
18 600
25 100
26 400
2760
1475
1140
1400
7477
Nichtraucher 55 Pl
Raucher 31 Pl
1750
26 100
150

Beilage 1

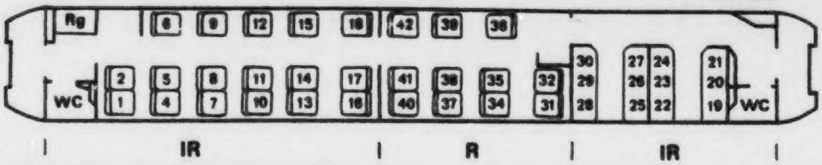


max. 1125
680
330
450
80
160
440
min. 8
max. 10
min. 12
max. 18
170
530
320
1087
1080
7
60
960
60
450
60
450
122
250

M 1:5
7.11.80 ZIW/Wy

SWEDEN

A2

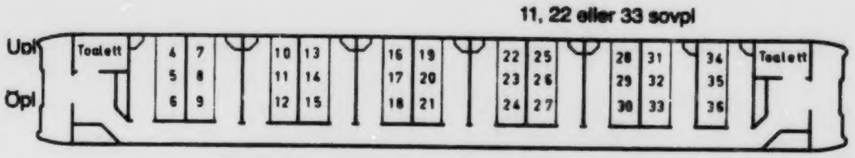

1 kl – 40 sittpl

R i korridor

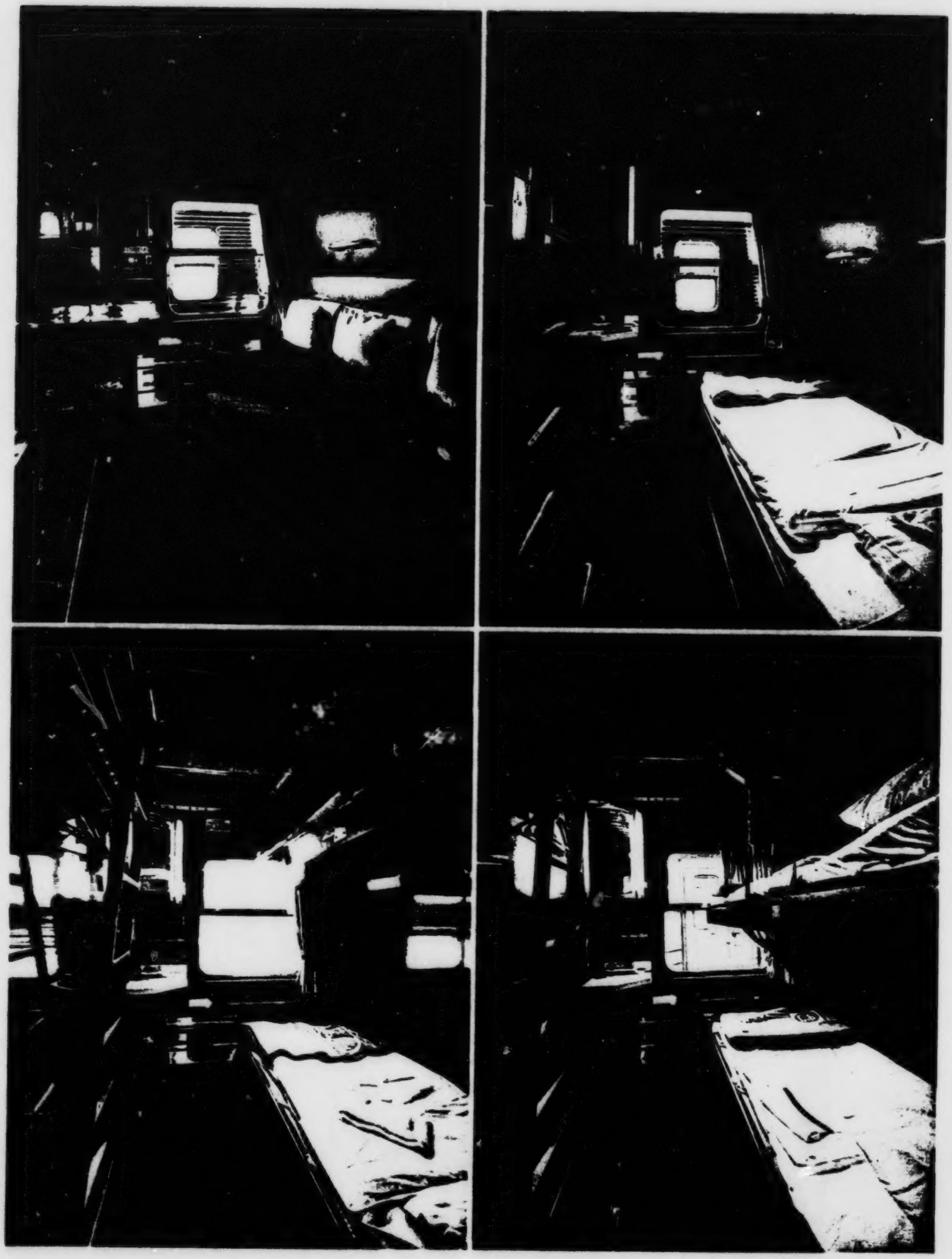
Rg
6
9
12
15
18
42
39
36
WC
2
1
5
4
8
7
11
10
14
13
17
16
41
40
38
37
35
34
32
31
30
29
28
27
26
25
24
23
22
21
20
19
WC
IR
R
IR

I kl sittvagn av modernaste typ. Fäll- och vridbara fåtöljer i salongerna, ställbara soffor i kupéerna. Garderober. Lysrörsbelysning och läslampor. God ljudisolering. Automatisk värmereglering. Ventilationsanläggning.

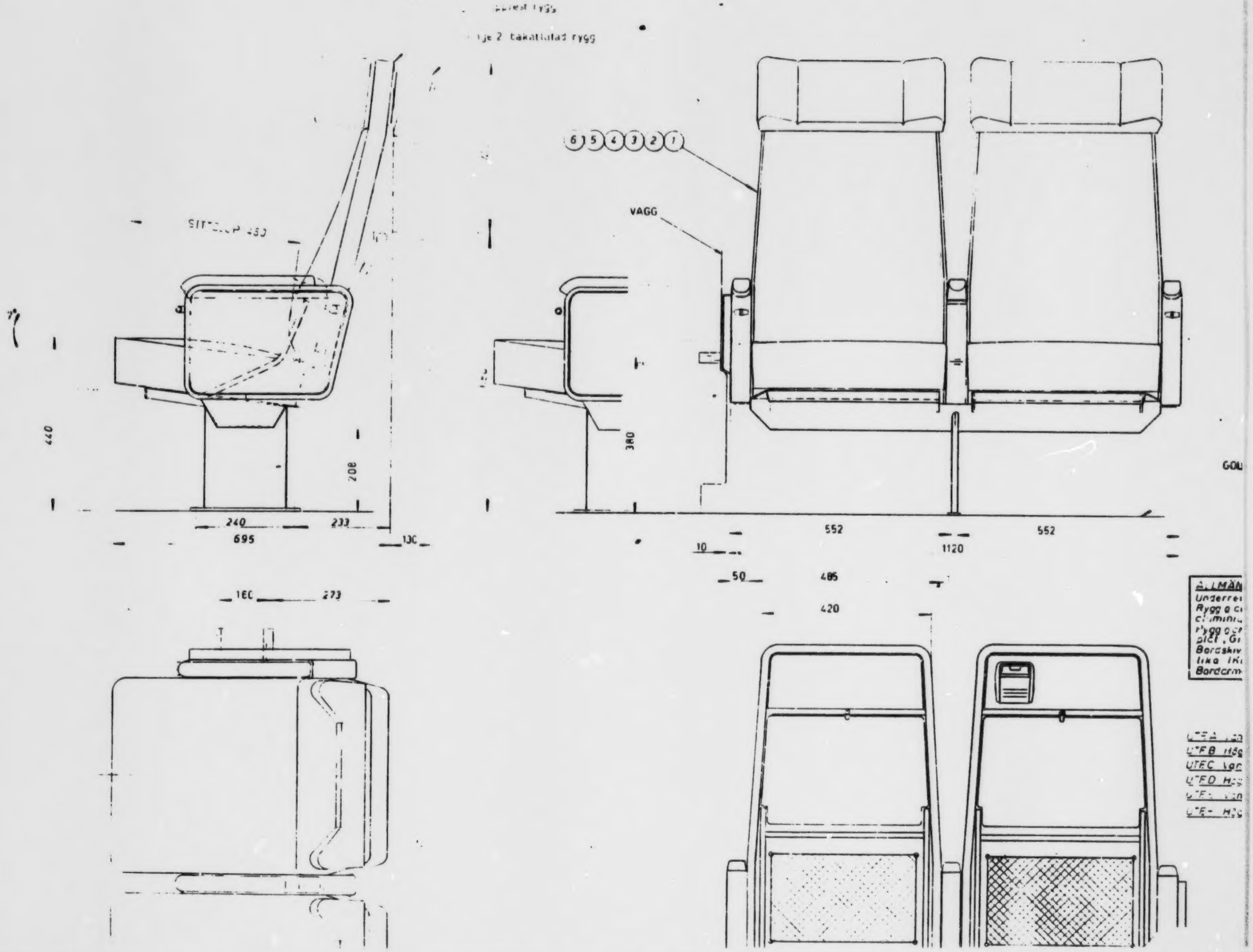
WL1


11, 22 eller 33 sovpl

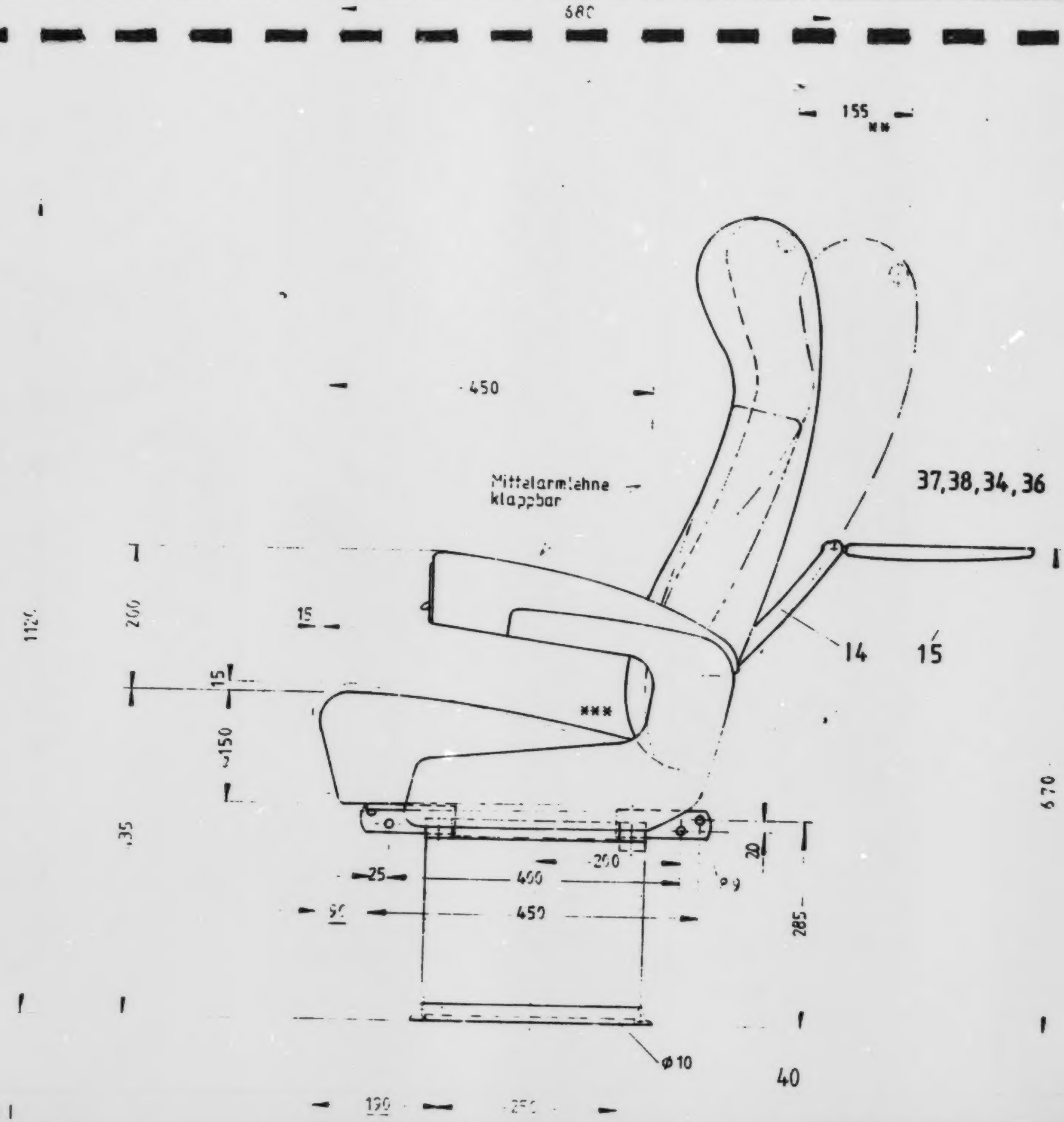
Upl
Öpl
Toalett
4 5 6 7 8 9
10 11 12 13 14 15
16 17 18 19 20 21
22 23 24 25 26 27
28 29 30 31 32 33
34 35 36
Toalett

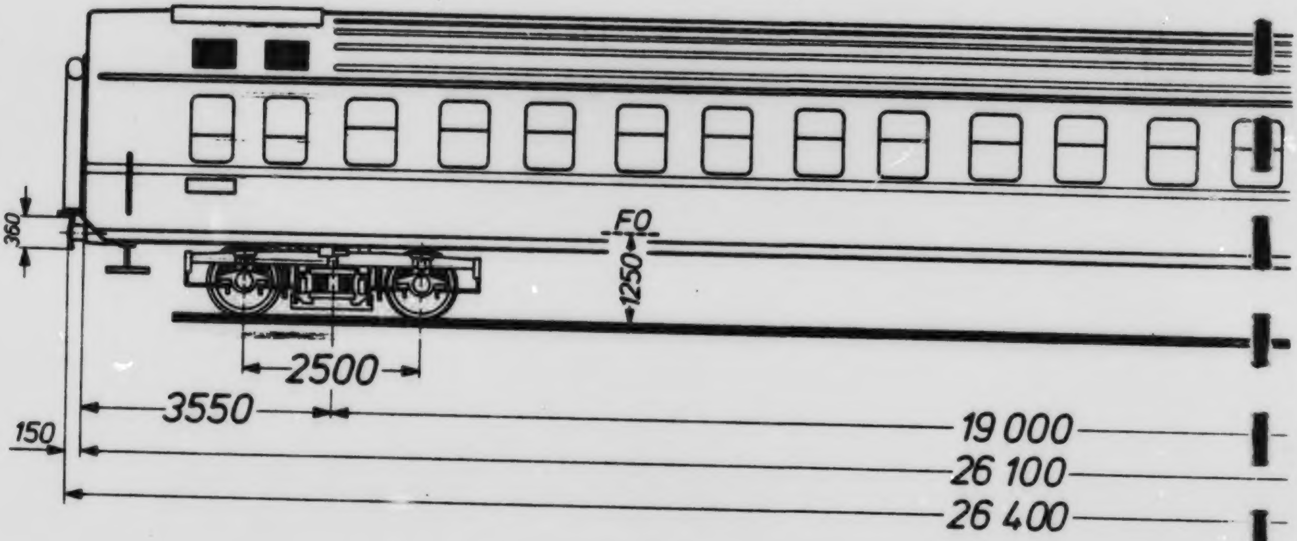


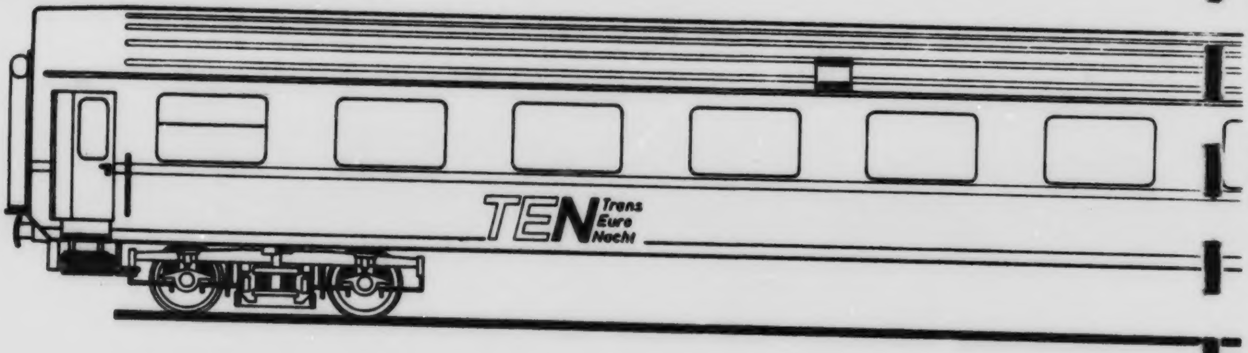
SJ modernaste sovvagnar. Rymliga kupéer, som efter behov kan bäddas för en, två eller tre personer. Bekväm, ställbar sittsoffa för dagbruk. Lysrörsbelysning. Automatisk värmereglering. Ventilationsanläggning. Rakapparatuttag. 110 och 220 V.

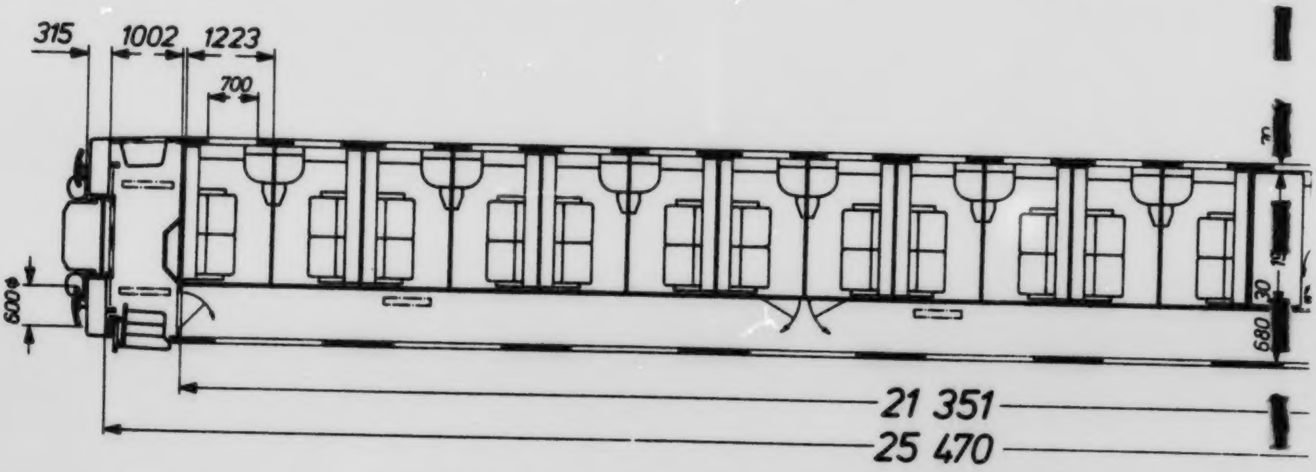
...rest rygg
...je 2 bakåtfälld rygg
SITTDJUP 450
VAGG
6 5 4 3 2 1
440
208
240
233
695
10C
380
552
552
1120
10
50
485
420
1EC
273
GOL
ALLMÄN
Underrei
Rygg o c
c'umini
rygg oc
plct , G
Bordskiv
lika IK
Bordcrm
UTFA
UTFB Hög
UTFC Lån
UTFD Hög
UTF
UTF- Hög

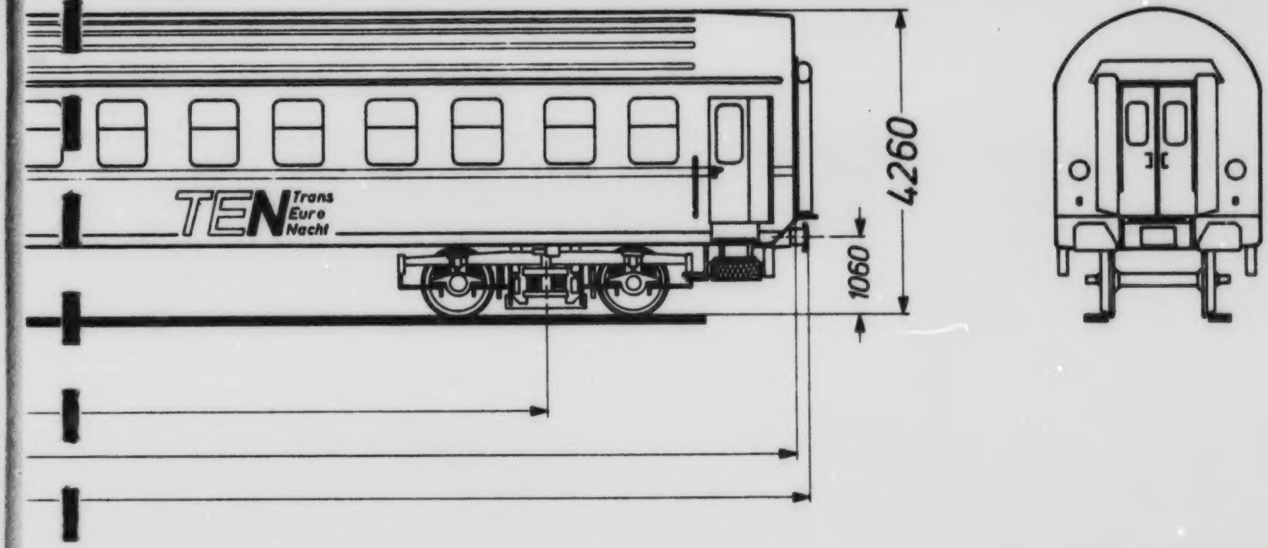
WEST GERMANY

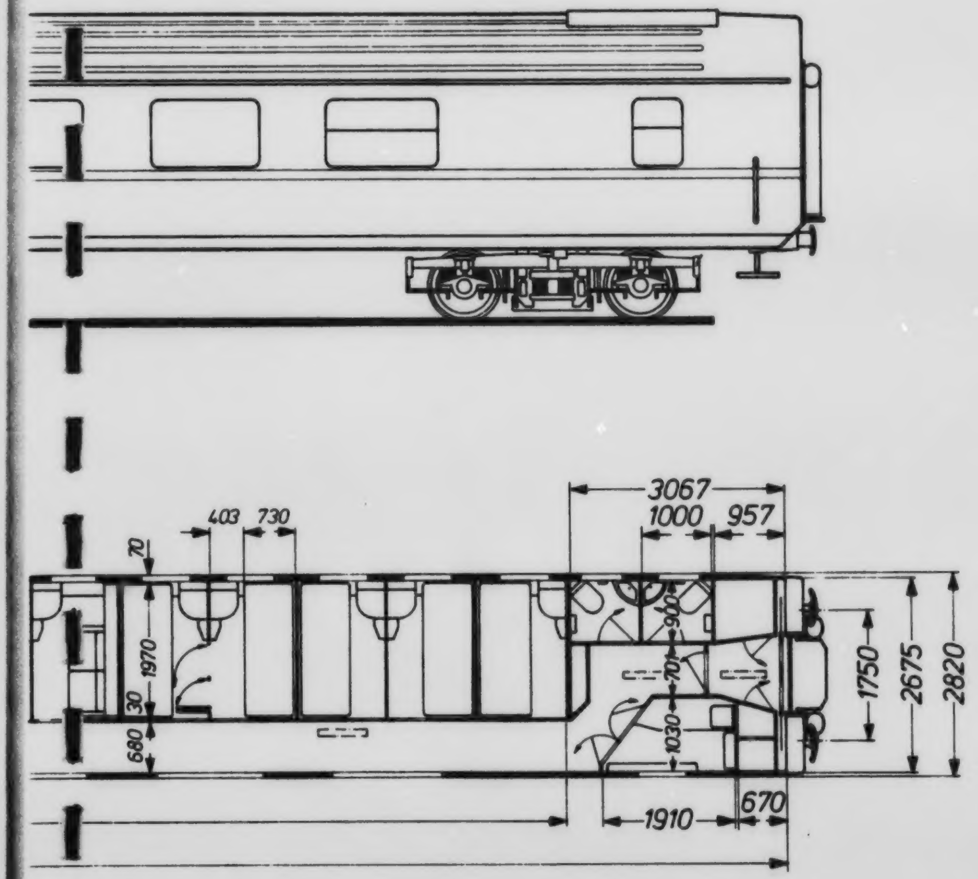

155 **
Mittelarmlehne klappbar
37,38,34,36
~150
***
ø 10


360
FO
1250
2500
3550
150
19 000
26 100
26 400


TEN
Trans
Euro
Nacht

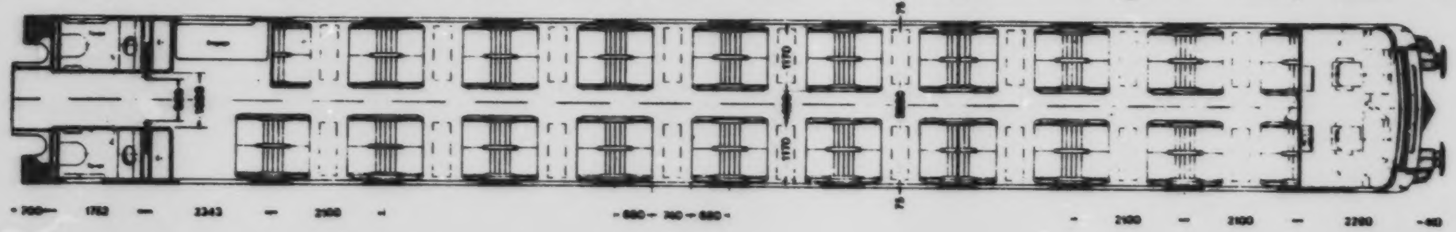

600φ
21 351
25 470


TEN Trans Euro Nacht
4260
1060

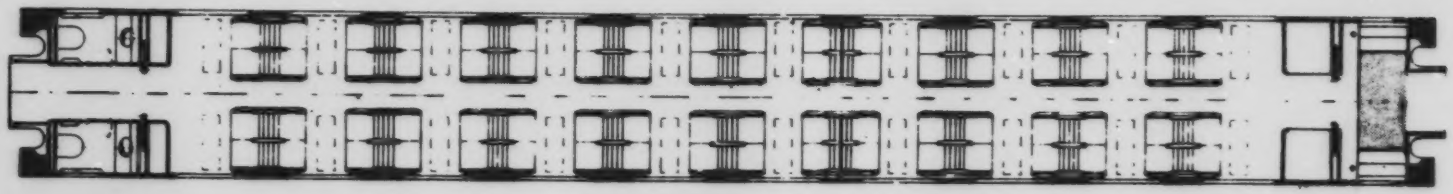

3067
1000
957
403
730
70
1970
30
680
900
70
1030
1750
2675
2820
1910
670

WLABsm 166
Schlafwagen T2S

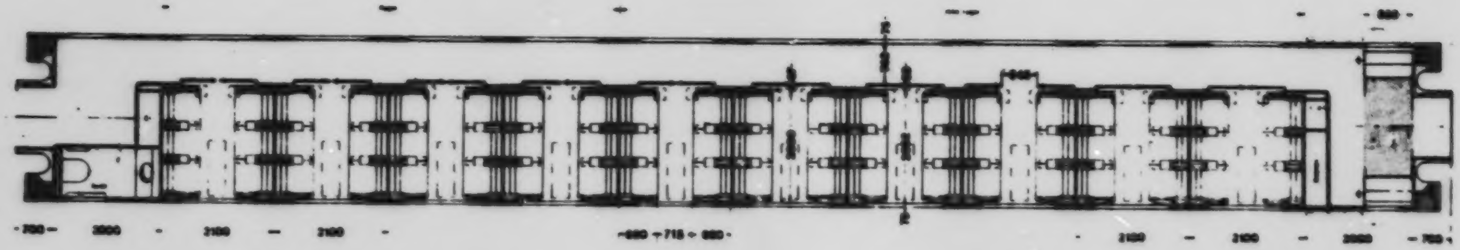
DENMARK


700
1752
2343
2100
880
740
880
2100
2100
2280

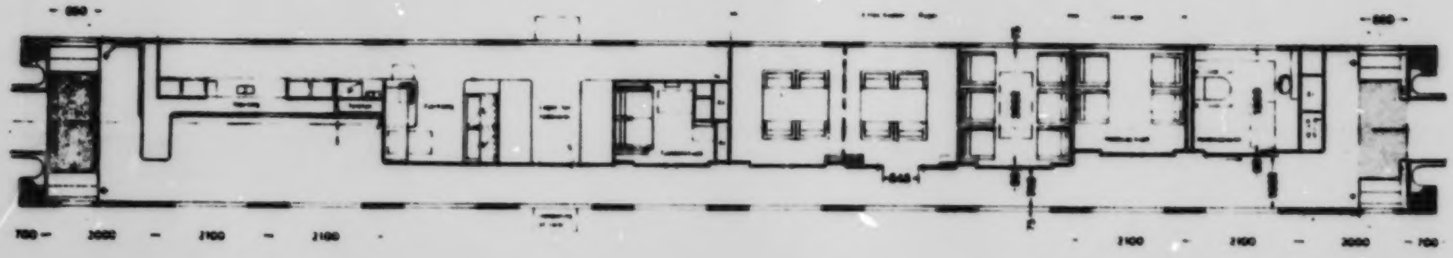
**Styrevogn
litra Bfs**



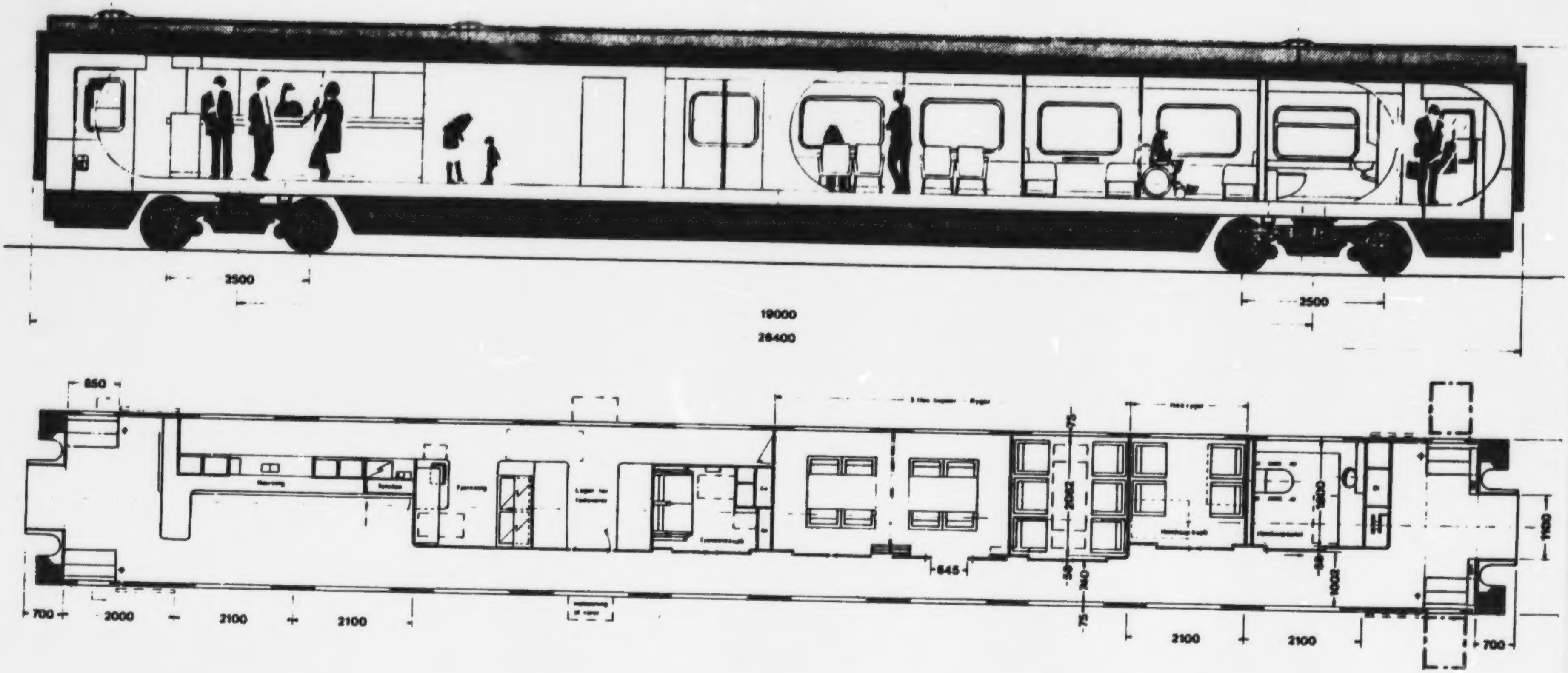
**Mellemvogn
litra Bfm**


880
700
2000
2100
2100
880
715
880
2100
2100
2000
700

**Mellemvogn
litra Afm**


880
880
700
2000
2100
2100
2100
2100
2000
700

**Servicevogn
litra Cfm**


2500
2500
19000
26400
850
700
2000
2100
2100
645
75
58
240
2082
75
1100
1800
58
1002
2100
2100
700
1100

Servicevogn
litra Cfm

Comparison of Canadian and International Rail Passenger Systems

TABLE OF CONTENTS

1. Background 1

2. Present Canadian Rail Services 3

3. Long-Distance Trains in Canada and Around the World 5

   3.1 Operating Conditions 5
   3.2 Passenger Characteristics 6
   3.3 Accommodation Levels 8
   3.4 Equipment Designs 10
   3.5 Service Delivery 11

4. Conclusions 12

COMPARISON OF CANADIAN AND INTERNATIONAL RAIL PASSENGER SYSTEMS

1. Background

Like the railways in most other countries, the Canadian railway system developed at a time when trains had great advantages over all other modes of travel for long journeys. Trains quickly replaced horse-drawn carriages and steamships as the preferred means of travel. Steamships still made ocean crossings and carriages were used for shorter trips. But, passenger trains could provide faster, more dependable, and cheaper travel between cities and towns. Trains quickly became the dominant mode of transport for hauling passengers and goods.

The railways continued to have a virtual monopoly on inter-city transportation until after the First World War. Then a network of paved roads began to be constructed. More than any other factor, the automobile has been responsible for the decline of railway passenger traffic and hence of services (Transport Canada, January 1976.)

There has been a similar course of events in many other countries, particularly the US, Japan, and the countries of Western Europe. Buses and automobiles have various advantages over trains in many situations. The relative level of government investment in roads versus railways plays a major role in the differential cost and comfort of travel by different modes.

In more recent years (since the '50's) passenger airline travel has further reduced the market share of the railways in many countries. The competition from airlines on longer routes overland has been most severe in North America. Until the creation of Amtrak in the US and VIA Rail in Canada, North American passenger rail services were in a serious state of decline. As a result of these efforts to revitalize passenger train services, their share of the passenger market has again started to increase. Transport Canada has predicted that rail will show the largest percentage growth of any of the passenger transportation modes over the next 15 years (Economic Analysis Directorate, Transport Canada, 1983.)

Public policy in Europe and Japan has been more supportive of railways for a long time. This has included such things as controls on airline prices, large capital investments in new equipment and rights-of-way, and, in Europe, good international railway connections.

Since railways were first constructed, public policy has played a decisive role in their development. In Canada, construction of major railways served national and partisan political goals. Lukasiewicz (1976) maintains that public policy, initially a major stimulus to railway development, has failed to keep pace with technological progress and has become a powerful deterrent to modernization.

The author claims that in Canada, a workable plan for elimination of obsolete passenger rail services was ignored since 1961 (following a report by MacPherson's Royal Commission on Transportation.) Policies considered politically more expedient have continued to protect obsolescence. In his view, this has resulted in maintenance of poor quality transportation and has proved extremely expensive to the public.

Behavioural Team do not regard all interventions by elected leaders as ignorant meddling. On the contrary, they are often responsive to public sentiments and future visions which have legitimate roles in technology development.

Lukasiewicz suggests that in the long term, passenger rail policy in Canada must be concerned with the potential of modern, fast trains. Capital investment and operation would entail losses (and thus subsidies) comparable to the losses now sustained in the present operation of passenger rail throughout Canada. Thus, modern rail, which would provide superior service, save energy and oil, and generate new industrial activity, appears at present, as an expensive proposition. Nevertheless, public funds would be used more productively on gradual development of fast rail links than on support of obsolete and deteriorating services.

As travel levels and oil prices increase, the potential of fast rail will continue to grow. In the long term, fast rail may frequently be chosen as a socially desirable and technically superior mode of passenger travel. There are activities underway in the US to develop and construct new high-speed lines on several of the more heavily travelled corridors (eg. Los Angeles to San Deigo.) These various ventures were the subject of a conference session at the 1983 meeting of the Transportation Research Board in Washington.

The high-speed trains of Britain, France and Japan are well known. They provide frequent, comfortable and fast service that competes effectively with other modes for those routes.

The world's fastest passenger trains, the French TGVs (Train Grande Vitesse), have logged an impressive record since they began operating in September 1981. Eighteen months of accident-free service with a punctuality record of 97.5% attest to the success of the technology and the quality of management responsible for the TGV enterprise (Lukasiewicz, June 1983.) When Jean Bouley, secretary general of the Paris-based International Union of Railways (UIC), was asked in Ottawa recently what he would do if he were president of Via Rail Canada Inc., he said his highest priority would be to determine the potentially most profitable high speed rail route in Canada and construct a line there exclusively for high speed trains. He also noted that the average passenger is far more interested in short travel time than in on-board frills and services (Lukasiewicz, June 1983.) What now needs to be determined is whether behavioural data can be collected to verify these subjectively based impressions.

The development of the LRC has been a step in the right direction for faster and more comfortable corridor traffic. Like a few other trains in the world, the LRC has tilting mechanisms for negotiating curves at higher speeds. However, all of the trains with "active" tilting mechanisms are experiencing "teething" problems. Other approaches to high-speed rail service here in Canada have other impediments, as dicussed below.

There are, of course, several other issues besides speed in the design of rail equipment and systems. Although passenger trains are designed for transporting people, human-factors have not always been the primary concern in design decisions. Political, economic, social and historical factors may also constrain or shape the designs.

An example of this sort of constraint is the change of gauge between many European countries. These changes were apparently planned by early British rail designers to prevent armies from invading other countries by rail. Many countries in central Europe have adopted a standard gauge. But the remaining gauge changes still have human-factors implications.

The overall design envelope of the train cars is determined by the gauge. The longer beds in Swedish sleeping cars are due more to the wider rail gauge than to Swedes being taller than other Europeans. Similarly, the Spanish Talgo sleeper cars have beds on the diagonal. Although this provides an improved ride in terms of yaw accelerations, the design was based more on the car width constraints than on studies of the body accelerations of sleeping travellers.

However, human-factors are playing more and more of a role in train design. Many national railways have commissioned surveys and studies to determine the role of various design factors in passenger comfort and satisfaction. In other cases human-factors concerns are identified through analysis of accident reports and passenger complaints.

In some countries the approach has been more scientific and systematic, while in other countries design decisions are based on the judgment of a few senior personnel with only trivial (if numerous) market research surveys to guide their judgment.

These varying approaches, and the constraints acting on railroads in different countries, have led to a wide range of designs for passenger equipment and approaches to service. Some of these designs may be appropriate for new Canadian equipment.

2. Present Canadian Rail Services

Passenger rail services in Canada can be divided into seven categories:

--- National services: these are the very long distance services which link the various parts of the country (the transcontinental and the Montreal-Maritime services)
--- Corridor services: these are the inter-city services which operate within the Quebec City to Windsor corridor
--- Inter-city services: these are the services between major centres outside of the corridor
--- Regional services: these are routes that typically radiate out from a major city into the surrounding countryside or link small regional centres
--- Overnight regional services: these are overnight trains serving areas of the country away from the main national routes
--- Remote services: in these cases no other form of transportation is available for some or many of the communities served

--- Other services: these are services between the core of a major urban area and its peripheral residential zones.

According to a report by Transport Canada (1976) the most suitable roles for passenger trains in Canada are in the provision of:

--- high speed services in areas of high population density over short to medium distances, where there are large volumes of travellers
--- basic surface transportation over long distances, where service levels somewhat above those on a bus are required
--- high capacity commuter services in large urban communities.

Passenger trains are not suitable for the provision of:

--- low density services between smaller centres where buses could provide cheaper, more frequent, and more convenient services
--- services outside of urban areas with a large number of local stops
--- longer distance services for time sensitive travellers.

Thus the long Eastern and Western transcontinental routes appeal to travellers who are not extremely sensitive to the trip time, but wish more comfort than that provided on buses. Shorter trips along these routes may be chosen for a variety of reasons (eg. inter-city or corridor traffic.)

The longer routes have clear peaks in passenger demand. These Summer and Christmas peaks indicate that there are basically two groups of passengers, regular users and holiday travellers. Decisions about how to deal with this seasonal demand also have design implications. In a report for Alberta's Economic Development Transportation Services, John Day has analyzed several options for the Western transcontinental services. His report deals with economic and marketing issues, and options for new equipment and schedules.

A similar analysis appears in a Science Council working paper "Passenger Rail Equipment Options for Canada" (1982.) Both papers suggest new equipment that requires less staffing and can be operated more economically. Double-deck cars offer one solution to the staffing and economy issues. The human-factors problems and issues involved in a double-deck car are often different than those for a single level car. This is another example of the overall design envelope having implications for the details of the accommodation space.

All of the above considerations may limit the applicability of train designs and practices in other countries to the design and operation of new long-distance equipment in Canada.

3. Long-Distance Trains in Canada and Around the World

3.1. OPERATING CONDITIONS

Most of the countries in the world are smaller than Canada. As a matter of fact, the countries with the most advanced rail systems are smaller than many of the Provinces. There are many countries where you can't travel on a train for six hours without crossing a border. There are very few where you can travel for six days. The most comparable long-haul train trips are the routes across the Northern US, and the trans-Siberian in Russia.

On many European routes the border crossings do not entail a change of trains. On overnight trips you often don't even have to wake up. The crew member takes your passport in the evening and returns it in the morning. The ease of crossing borders in parts of Western Europe make long-distance trips there more comparable to the Canadian situation.

In other places, such as New Zealand and Australia, there are also long distance trains, but the climate is less severe there in the colder months than in Canada.

The climate, distances, and economic base of the railroads all have effects on track conditions and power options. These, in turn, affect ride quality. Most of Europe has smoother track than Canada. Passenger lines usually have continuously welded rails. And passenger schedules have priority over freight. This permits a faster, more comfortable ride. The most modern systems, such as the TGV in France and the Shinkansen in Japan, have dedicated tracks that are specially designed and maintained for high-speed passenger operation. In Canada, on the other hand, many tracks are bolted. This may allow them to stand up better to freezing and thawing cycles, but gives a rougher ride.

In addition to the track limitations, signal systems in Canada are designed for slower freight trains. Since Canada probably has more kilometers of track per capita than any other country in the world, upgrading of the track is proportionately more costly. Operating conditions in the foreseeable future can not be expected to approach the more ideal conditions found elsewhere.

The same considerations apply to electrification of routes. The shorter distances and heavier traffic in Europe and some US corridors make electrification economically viable. But possibly in Canada, the distances may be too great and the traffic too small to justify the expense of electric transcontinental trains.

We do not advocate ignoring the situation, but we recognize the inherent difficulties under Canadian operating conditions. Every effort should be made to improve tracks and signalling systems to allow for faster and smoother passenger travel. New developments in rail placement and maintenance, car suspension, and signalling should be followed. Anything that would make passenger trains smoother and faster would enhance passenger satisfaction.

Another constraint caused by Canadian operating conditions concerns the interaction between climate and the cleanliness of the train's exterior. Comparable conditions exist in Sweden and some other Northern countries. The snow and slush splash up from the rails and dirty the cars and windows. But the weather is sometimes too cold for washing the cars outdoors. Even large automatic washing equipment will not work at extremely low temperatures. In France and many other countries, an anti-freeze solution is added to the washing water at these automatic cleaning facilities. But the anti-freeze only works to about -10° C. Perhaps alternative cleaning procedures and equipment could be developed that will solve this climate related problem.

The major implications of Canadian operating conditions are, of course, economic. We have large distances and a relatively low population density. We cannot expect to have the same level of rail equipment, service and speed that are enjoyed by countries such as Japan. However, we should try whatever means are justified to improve equipment, service and speed.

3.2. PASSENGER CHARACTERISTICS

There are certain groups of people who are likely to be train passengers in any country. They are the so-called "captive market." They include students, seasonal workers, elderly and mildly handicapped persons, and others who don't take their trips by car or plane for reasons of economics or personal phobias. These passengers may use buses on routes where bus travel is cheaper or more convenient. In some parts of the world, including parts of Canada, trains are the only form of access to some communities.

Most railroads also have a significant group of discretionary vacation travellers. They choose the train because it offers a better view, more spacious accommodation, or more economical transportation than other modes such as air, bus or auto.

Buses can compete fairly well for long day trips in most countries. In some places, such as Denmark, the main bus company is a subsidiary of the national railway. The government can thus control the competition to a greater extent. This also encourages multimodal services and stations. Buses do not compete so well on overnight trips, because passenger space and sleeping accommodation is less adequate. Development of new types of sleeper buses, as suggested in a recent Science Council report, could change this situation, but the train will probably always be more comfortable.

Schedules, trip time, and cost are more important than space and comfort for many travellers. Improvements in any of these areas can entice passengers away from other modes. In Europe and Japan there are many business men and women who travel by inter-city or overnight trains. In Europe, the distances between major city pairs and the schedules are conducive to leaving in the mid to late evening, getting a full night's sleep, and arriving downtown early in the morning. The fares are cheaper than airlines, and the connections are more convenient. The trains have comfortable sleeping accommodations, even in 2nd class.

On day trains in Japan and Europe there are often special facilities available for businessmen to work on the train. The new Danish Lyntog, and the Japanese Shinkansen trains are probably the most advanced in this area, with conference rooms, projectors, phones for making or receiving calls, etc. Some railroad companies will even arrange for hire of a secretary to accompany you to take dictation, type memos, and the like. If the time on the train can be seen as productive, rather than wasted, business people find the train more attractive.

These special features for business travellers are available on a reservation basis. If there is no call for them on a particular journey, the "conference" compartments can be used as regular 1st class compartments, snack bar service areas, etc.

There are a few instances of "dedicated" spaces for special groups of travellers. Some railways, such as DB in West Germany and DSB in Denmark, have a special area in a few cars and special toys and facilities for children's play. These are quite limited and experimental services. Many trains have a special compartment for mothers and children, with a fold-down changing table in the nearby washroom. Some of these even have a private nursing area. Such facilities make a long trip more enjoyable for travellers with small children. In addition, it shields other passengers from crying infants and yelling, running toddlers. A specified compartment or play area for small children should permit a variety of normal play behaviours, such as climbing, walking, or sharing toys on the floor. In ordinary open coaches, as in other places with an aisle between rows of seats, young children tend to resort to running up and down the aisle for exercise and entertainment.

In several countries it is possible to reserve an entire snack bar or lounge car for a travel group or a travelling party. In most cases this takes considerable lead time to arrange. On trains with compartments it is fairly easy to reserve a compartment for a small group travelling together. In some cases, pairs of adjoining compartments can be combined for slightly larger groups by folding away the dividing wall.

All of these options make the train more attractive for some travellers. The probable positive effects in terms of more rider revenue need to be weighed in terms of additional design, construction, and operating costs. These economic considerations also affect provision of services and equipment for the handicapped. The degree to which the needs of the handicapped are met in different countries depends on how much weight is put on these economic factors.

In West Germany, for example, special facilities for wheelchair passengers are viewed as not in sufficient demand to justify the expense. On the other hand, in Denmark, Sweden, Norway, and some other countries, there are cars specially designed for wheelchair access. They have hydraulic lifts, wider doorways, special washroom facilities, etc. They obviously do not attract enough additional passengers to return the extra investment, but they have been included to allow the handicapped more widespread access to transportation.

In terms of strictly ergonomic differences between Canadians and the passengers of other countries' railroads, there has not been much systematic research. Other studies suggest that North Americans are somewhat taller and heavier than most Europeans, but most of these studies are based on dimensions of military recruits. It is safe to assume that purely physical features do not differ greatly between Western Europe, the US and Canada.

The more social and psychological human-factors certainly show more variability from country to country. An example is the sharing of sleeping accommodations. In Europe this sort of sharing is taken for granted in design and operation. Even in 1st class sleeping cars there are few spaces dedicated to single passengers.

The occupancy (single, double, triple) is determined by how many of the beds are prepared. Consequently, single accommodation is proportionately more expensive than in Canada.

In the 2nd class sleeping compartments, (couchettes) the sexes are mixed and passengers don't change into other clothes for sleeping. In 1st class compartments, or couchettes with only males or only females, passengers take turns using the floor space, sink, etc.

The upper and lower berths, or "sections", and the roomettes on Canadian sleeper cars demonstrate some perception on the part of their designers that privacy is more important than space. The result is less than ideal. The berths don't have enough room to change clothes and the seats that are there in the daytime are not comfortable enough for long trips. The curtains provide visual privacy but smoke, smells, and noises can pass through. A "sleeping capsule" approach might be better in terms of privacy. But the more flexible arrangements possible with compartments that can seat and sleep several passengers comfortably should be investigated further. Specific market segments should be studied indepth (not by mass survey) to see if the relevant portion of the travelling public is willing to share a sleeping compartment with strangers.

Passenger characteristics are related to the level of accommodation provided. Some passengers want the cheapest basic transportation available. Other passengers are willing to pay more for more space, better service, more comfortable sleeping, and/or isolation from those passengers needing the cheapest travel. This raises questions both in terms of designs and price structures, and in terms of the way the different levels are presented to the travelling public.

3.3. ACCOMMODATION LEVELS

On European trains there is a clear and consistent differentiation based on the simple division between "1st class" and "2nd class." The cars are usually labeled on the outside as 1st or 2nd class, and are often painted different colours. Most stations have signs showing the layout of the train in terms of the type of car, or the specific car number. This makes it much easier to find your place on the train.

These terms are somehow more offensive to North Americans who like to view their society as "classless", or at least, less clearly divided into a first and second class. This has resulted in terms such as "day-niter class", "coach class", "lounge class", "empress class", "economy class", etc. These may seem less offensive but they are also more confusing.

Since different levels of accommodation are necessary to attract maximum passengers, some clear terms should be chosen to differentiate the levels of accommodation. Perhaps calling them "class A" (Additional fare) and "class B" (Basic fare) would provide a simple differentiation which could be clearly indicated in signs, tickets, and rail cars without offending too many passengers.

The actual differences between the class A and class B accommodations raise another set of questions. In open seating coaches the most general pattern is to have 2+2 seating in 2nd class and 2+1 seating in 1st class. This involves wider seats, but not always a wider aisle. The pitch of the 1st class seats is usually greater, as well.

Modern European trains are moving toward more open coaches and fewer compartments for daytime trips. The Swiss designs with a full partition and glass door between smoking and non-smoking compartments divide the coaches into two smaller seating areas. Besides the advantages for air quality in the non-smoking section, this makes the accommodation space less like a long auditorium, without significantly decreasing seating density.

Most of the European seating cars actually in service on longer trips have closed compartments along a corridor. The 1st class compartments usually seat six passengers. Second class cars also usually have compartments for six, although some seat eight. The typical differences between 1st and 2nd class seating compartments are in the seat design and construction, interior materials, and the length of the compartment (1st class has more space between the opposing seats.)

In Canadian seating coaches, the differences between the 1st and 2nd class seats is often greater. The day-niter seats with leg rests are among the most comfortable seats for sleeping. Of course, most other railways don't have seats designed for sleeping. They have seating compartments which convert to couchettes or bedrooms.

European railways have two classes of sleeping cars, also. In fact, many countries now share sleeping cars from a common pool. The 1st class sleepers have rooms that can be made up for one, two or three persons. The 2nd class sleeping cars have compartments that seat and sleep six to eight passengers. Canadian trains have more like four classes; day-niter, section, roomette, or bedroom.

The newest Amtrak equipment on long trips is the Superliner, which takes the Northern transcontinental route. It employs a double-deck design with bedrooms and roomettes on the upper level and roomettes on the lower level. The dining cars have a dining room on the upper level and the kitchen and storage on the lower level.

The DB in West Germany handles the design and construction specification of many of Europe's sleeping cars. They are also considering double-deck designs for their next generation of sleeping cars. A double-deck design also permits additional segregation for the higher paying passengers if the transit through the car is restricted to the lower level. The passengers in the upper level get more privacy and a better view.

The placement of the cars in the consist is often related to the class of fare. It is common to place the 1st class cars, especially sleepers, at one or the other end of the train so other passengers won't have to walk through on their way to the dining or lounge cars. Dining and lounge cars, themselves, are seldom restricted to either class of fare, but 1st class passengers usually have priority for dining reservations.

A higher level of service is generally provided in first class sleeping cars in Europe. However, some countries (eg. Sweden) do not provide a porter for each sleeping car, in order to reduce staffing costs. The passengers are expected to bring their own food and drinks.

In general, then, it seems that space differences are only a small part of the distinction between 1st and 2nd class rail travel. The level of service and privacy is usually greater. And the interior furnishings and materials are more comfortable and attractive. The precise preferences of the Canadian rail passenger market cannot be predicted from the levels of accommodation offered elsewhere. It would be valuable to have more information about what features are desirable in 1st class, and how much more passengers are willing to pay for them. Another facet of the question concerns the minimal acceptable accommodation in the basic or 2nd class.

3.4. EQUIPMENT DESIGNS

There are some basic trends in equipment design in modern long-haul passenger trains. Many of these features have already been adopted in newer Canadian equipment, such as the LRC, and in refurbishing of older equipment.

The main design features are described below, in the order of the previous taxonomy of human-factors issues. The features that do not appear on any Canadian equipment are marked with an asterisk.

- electric heating and air conditioning, no passenger operated controls in open coaches, passenger operated control in sleeping compartments for ± about 5 ° C.

* specific coach and ventilation system design to keep tobacco smoke away from non-smokers.

* continuously variable fresh air intake, with some proportion of fresh air even at extreme temperatures.

- more sound insulation, especially in sleeping cars.
- loudspeaker systems for announcements to passengers.

* individually supplied music.

- incorporation of materials and designs to minimize vibrations and accelerations.

* sharing bogies between adjacent cars to reduce the proportion of passenger space over a bogie.

- individual reading lights.
- large tinted windows with shades or curtains.
- graphic signs using black for the pictogram and red to indicate prohibitions or warnings, backlighted signs in white on black.

* double-deck coach, sleeping, and restaurant cars on compatible long-distance routes.

- wheelchair accessibility to some washrooms and seating areas, with special tie-down mechanisms in the seating area.

* infant changing tables in some washrooms.

* self-contained toilet systems that can also be used while in the station.

* showers in some (1st class) sleeping areas.

- snack bar areas within seating coaches.

* children's play area in some cars.

* combination of restaurant and snack bar service in the same area.

* special adaptations to restaurant cars for conferences, parties, special entertainment, etc.

* sleeping compartments that can be made up for one to three (1st class) or one to six (2nd class) passengers.

* some cars with economical 2nd class roomettes for two.
* graphic aids for locating your car in the consist.
* wheelchair lifts incorporated into the door mechanism.
* fold-down lower step at entrance.
* visually accessible common luggage racks in coaches.
- more pre-made meals (except in a few countries like Switzerland and US where they still really cook on the trains.) Note: many people do not regard microwave cooking as "progress."
- drinking water in all passenger cars.
- automatic doors between cars.
- special floor covering in doorways for safety and easy maintenance in winter conditions.
- ergonomically designed seats with simple adjustments.
- some work/play tables in coaches between opposing seats.
* special handholds on seat backs for passengers walking down the aisle.
* special cars for carrying passengers' autos to vacation areas.
* the assistance of behavioural professionals in interpreting public sentiments into design.

This is just a brief overview of some of the general features of modern passenger equipment. Canadian equipment has already incorporated about half of the items mentioned. There are many more specific details available concerning the variety of equipment in operation in different places, much of which has been reported previously (tasks 4.3 and 4.4.)

3.5. SERVICE DELIVERY

The services provided, the training of staff, and their interactions with passengers all differ greatly from country to country. There are some general characteristics, however. Train crew usually wear an informal sort of uniform that identifies them. The official hat is usually the clearest indicator, but you can tell by the colour and style of clothes if they don't have their hat on. (That's if you know what colours and tie insignia to look for.)

Most people do not receive special boarding assistance from the crew. If a handicapped person needs assistance they usually need to call ahead and ask for it. Many sorts of special help can be arranged in advance. This even includes care of unaccompanied children.

Few railways provide on-board announcements concerning delays, points of interest, or revised schedules. However, many railway officials acknowledge that the passengers would appreciate improvements in this area. Arrivals are announced on many trains, sometimes in up to five different languages.

Many train companies produce their own on-board magazine, which provides information about the railway, seasonal events, and general interest reading material. Advertising revenue offsets the production costs.

Most railway companies have instituted some special training for staff in human relations, assisting the handicapped, etc. In Europe, most of the train crew members have some abilities in second and third languages, with German, French, and English being most common.

The level of staffing required has been recognized as an important economic issue. In some places, such as Sweden, sleeping cars may have no crew members besides the train conductor who visits all the cars at the start and end of each trip. Consequently, the price supplements for Swedish sleeping accommodation are less than for the sleepers operated by the French or West Germans.

4. Conclusions

The accommodations, facilities, services, and equipment of different rail companies have evolved under different conditions. The constraints operating in one country may be irrelevant in another. However, there are enough generalities to make comparisons worthwhile. Most railroad companies are in a continual process of considering designs for new equipment and modifications to existing designs. In some cases, human-factors research is considered in these designs. Some aspects of market research are always considered.

The best, simplest, and most easily maintained designs of specific details could probably be adopted directly. But decisions about the overall design envelope (eg. single level vs double-deck), and the levels of accommodation and service for the different classes of ticket, must be decided based on research specific to the Canadian situation and VIA's present and target passenger groups.

Design Guidelines for Long-Distance Passenger Trains

TABLE OF CONTENTS

1. GENERAL ENVIRONMENTAL VARIABLES

1.1 Temperature....................................1
1.2 Air Quality....................................4
1.3 Auditory Stimuli.............................. 6
1.4 Vibrations.................................... 7
1.5 Accelerations................................. 8
1.6 Lighting...................................... 9
1.7 Signs and Information.........................12
1.8 Other Visual Stimuli..........................14
1.9 Space...14
    1.9.1 Public Spaces...........................15
    1.9.2 Accommodation Spaces....................15
        1.9.2.1 Seating...........................16
        1.9.2.2 Sleeping Compartments.............17
        1.9.2.3 Rooms and Roomettes...............18
        1.9.2.4 Materials and Fabrics.............18

2. BEHAVIOURAL VARIABLES

2.1 Boarding and Leaving the Train.....................19
2.2 Locating Your "Territory" on the Train.............20
2.3 Handling Luggage...................................21
2.4 Activities in Accommodation Space..................22
    2.4.1 Sitting......................................22
    2.4.2 Reclining....................................23
    2.4.3 Reading......................................23
    2.4.4 Talking and Social Interactions..............23
    2.4.5 Playing Games................................24
    2.4.6 Sightseeing..................................24
    2.4.7 Work...24
    2.4.8 Self Care....................................24
    2.4.9 Care of Travellers with Special Needs........25
    2.4.10 Sleeping....................................26
    2.4.11 Intimate Social Behaviours..................26
    2.4.12 Smoking.....................................26
2.5 Transitions between Accommodation and Public Space....26
2.6 Activities in Common or Public Spaces..............27
    2.6.1 Aisles.......................................27
    2.6.2 Washrooms, Toilets...........................27
    2.6.3 Lounges, Snack Bars, Restaurants.............27
2.7 General Psychological Considerations...............28
    2.7.1 Regulation of Human Contact..................28
    2.7.2 Relation between Cost and Comfort............29
    2.7.3 Relation between Cleanliness and Comfort.....29
    2.7.4 Perceived and Actual Safety..................29

    2.7.5 Phobias and Fears..............................29
    2.7.6 Stress Reduction...............................29
    2.7.7 Entertainment, Festivities.....................30
    2.7.8 Special Travel Groups..........................30

3. INTERACTIONS WITH RAIL PERSONNEL

3.1 Identifying Help, Information, or Authority Figures...30
3.2 Training and Demeanor of Staff.........................31
3.3 Emergency Management...................................31

INTRODUCTION

This report contains human factors recommendations for the design of new long-distance passenger coaches. These recommendations are based on Behavioural Team's review of the literature and current practice. The previous interim reports (Appendix A to E) describe the "state of the art" in terms of research and practice both here in Canada and internationally. Our literature review relied on searches of large computer databases and specialized libraries. We have contacted not only major railways throughout the world, but also designers, manufactureres, and operators of other modes of transportation. All of these information inputs have been synthesized into the following guidelines.

The design guidelines are organized according to the same taxonomy that was used for the literature review and anlysis of Canadian and International practice.

1. GENERAL ENVIRONMENTAL VARIABLES

1.1. TEMPERATURE

The "ideal" or "most comfortable" temperature for train passengers depends on many factors. These include the age and physiological condition of the individual passenger, their type and amount of clothing, state of wakefulness, and activity level. Season, time of day, and length of time on the train also affect the individual's response to temperature. In addition, the placement and flow rate of ventilators, the relative humidity, and characteristics of the interior materials affect the passengers' temperature sensations. It is, therefore, necessary to specify a temperature range that will keep almost everyone happy.

It is obvious that efficient heating and cooling systems are very important to passenger comfort. Either heating or cooling is in operation most of the time on train journeys. For outside temperatures in the range 21-23°C, neither heating nor cooling need be in operation in passenger coaches, and all air will be fresh. At all other temperatures, the temperature, humidity, and amount of fresh air have to be controlled.

The following table provides some general guidelines for preferred temperature ranges.

	Outside (ambient) temperature in °C (low:high)						
mean inside temperature in °C (min:max)	-50:-10	-10:0	0:20	21:23	24:26	26:30	30:maximum
1st class coach	17:20	18:21	18:21	21:23	23:24	24:26	26:28
2nd class coach	16:19	17:20	18:21	21:23	23:24	24:26	26:28
washrooms	16:18	16:18	16:20	21:23	23:25	24:26	26:28
vestibules	15:17	16:18	16:20	21:23	24:26	26:30	28:32
sleeping compartments	15:24	15:24	15:24	16:24	16:24	18:25	19:26

Note: The temperature in sleeping compartments should be under the control of the passengers. Temperature in all other areas should be controlled by train staff.

The rationale for this temperature regime is as follows. The vestibules and washrooms should not have any additional appeal due to better heating in the cold weather or better air conditioning in the hot weather. The temperature there should make them a less comfortable place to be than in the coach or compartments unless they are intended as lounging areas.

The temperature in sleeping areas needs to be adjustable within a broad range. People differ more in preferred sleeping temperature than in preferred sitting temperature. If passengers are unable to sleep well because of the temperature they will certainly feel badly about their trip. The preferred temperature range is fairly constant across seasons and exterior temperatures. The increase in the interior temperature at the highest ambient temperatures is possible because of the passengers' adaptation level to warm weather. Extremely high temperatures generally only occur in the middle to late summer in Canada. During summer days these compartments can be maintained at a warmer temperature than at night, but the passengers should still have some control. Optimizing the environment in these compartments will attract some passengers to pay the additional fare.

The control itself should be simple and clearly labeled. The same control should be used for heating and air conditioning, with the warmer and cooler parts of the range at the extremes. If it is technically feasible, both heating and air conditioning should be available to the sleeping compartments at ambient temperatures between 18 and 24°C.

In the lower temperature ranges, seated passengers will likely be wearing heavier clothes and will be physiologically adapted to lower temperatures. The rise in temperature during the hot weather is also possible because of clothing and adaptation levels. It is also economical not to always keep the coaches at 22° or some other "ideal" temperature.

The suggested interior temperature range for the higher ambient temperatures is based on a simple rule - maintain the interior temperature midway between 22° and the ambient temperature. The minimal requirement during hot weather is that the inside temperature not exceed the outside temperature.

Train staff should be able to change the temperature in a coach, dining car, etc., based on feedback from the passengers. However, there should be some attempt to see if there is a consensus among the passengers. If only one or a few people are too cool, behavioural thermoregulation is more appropriate. That means they should put on a sweater or have a blanket for their lap.

It is important for the train staff to seek a consensus concerning comfortable temperatures before changing the thermostat. The staff person may be wearing a jacket and staying active while the passengers may be less dressed and more sedentary. The passengers would, therefore, prefer a higher temperature than the staff member.

There should be an accurate thermometer in a visible place in each car. Either a regular glass thermometer or a digital readout of temperature would provide the necessary reference to reduce any dissent about how warm or cold it actually is in the car.

Surface temperatures of windows should be high enough in winter so that uncomfortable drafts from the windows are eliminated. The temperature of the side windows should be raised during cold weather by installing two-pane glass with internal heating elements. An absence of drafts and clear window panes (i.e. no frost, dew, or ice) are essential for passenger comfort.

The thermal conductivity of the surfaces with which the passenger comes into contact such as floors, seats and rails, should be kept as low as possible. Plastic shell seats or metal handrails require higher inside temperatures during the winter and lower temperatures in the summer. Seat and bed covers also need an adequate degree of water permeability for thermal comfort. Impervious upholstery, such as vinyl, is not appropriate for long duration sitting or sleeping surfaces, but may be good for seats in dining areas and lounges. In these cases, the impervious cover is easier to clean.

For maximum comfort, there should be a difference in air temperatures in the lower and upper part of the passenger compartment with the difference becoming larger as the interior air temperature rises. For a mean air temperature of +20 °C, there should be a +4 °C difference in temperature between the head and foot zone. The heating should be introduced into the lower half of the occupant cell and cooler air into the upper half of the occupant cell.

These temperature recommendations are, of course, dependent on proper air quality. Humidity and ventilation interact with temperature to determine passengers' thermal comfort. At some moderate temperatures additional ventilation can compensate for less cooling of the air. But a good ventilation system alone cannot replace air conditioning in hot summer temperatures.

Heating, air conditioning, and ventilation can be powered from the locomotive or an auxiliary generator car. Equipment compartments in each coach should hold air conditioning packages designed to handle outside temperature extremes of -40 °C and +40 °C. Presently available heat-pumps have a more limited effective range. In addition, they produce significant vibrations. Therefore, conventional forced-air electric heating and air conditioning is recommended as the most economical and reliable.

1.2. AIR QUALITY

There are three major air quality issues for the design of long distance passenger trains: ventilation, humidity, and control of odours and pollutants. These issues are not independent from each other and also interact with systems for temperature control. Adequate fresh air intake is necessary to maintain air quality. The characteristics of this air and the amount of it in proportion to recirculated air affects the systems for controlling temperature, pollutants, and humidity.

An acceptable relative humidity for temperatures up to about 22°C is 50 to 65%. At higher temperatures the relative humidity should be slightly lower. At the maximum temperature range described above for air conditioned coaches (26 to 28°C), the humidity should be kept between 45 and 60%. These humidity ranges generally require adding moisture to the heated air during cold weather and removing moisture from the air in the summer.

If it is not deemed economical to heat the side windows during winter or to put air ducts under the windows, a lower humidity level should be adopted, between 25 and 35%. The higher levels mentioned above would lead to condensation on the inside of the windows unless countermeasures are taken. In addition, higher humidity would require carrying large amounts of water on the train for humidification.

Ideal air filtering or purification equipment should be capable of removing dust and pollen particles from the air. It should also remove odours arising from the passengers and their smoking. There are many types of filters on the market with varying claims concerning their effectiveness. These filters should be subjected to some evaluation. Unless this equipment can completely remove all perceptible traces of tobacco smoke, the air from the smoking sections of the train should not be recirculated.

Accumulated odours in upholstery, carpets, etc. should be removed periodically through steam cleaning and/or chemical treatment. Washrooms should be cleaned frequently during the trip to maintain their cleanliness and air quality.

If smoking is permitted in the vestibules and sleeping car corridors, ventilation design needs to insure that other passengers are not exposed to the second-hand smoke. There has been a great increase in public awareness about the negative aspects of tobacco smoke, especially on nearby non-smokers. This is particularly important for passengers who have paid additional fare for a room or a first class seat. Likewise, the air from the washrooms, dining areas, and kitchen should not be recirculated to other areas in the car.

It is important to make sure the air is clean, the right temperature, and the right humidity. The system for delivery of this air is also critical. As mentioned in the section on temperature, above, warmer air should be delivered at foot level and cooler air from above. Although it may be an expensive option, maximum comfort can be attained with individually adjustable air jets for the cooler air. This will permit some passenger control of their local thermal environment without actually changing the thermostatic setting for anyone else.

The individual air jets should allow for adjustment of aim and flow rate, similar to the air jets found in many commercial airliners. The passengers who are too warm can increase the air flow from their air jet or aim it more directly at their face and chest area. (This is the area that produces maximum cooling.) Passengers who are too cool can close the air jet or reduce the flow and aim the jet off to the side. The warmer air from the foot level heating vents will then rise to warm their immediate area. A narrow air jet should have a flow velocity of up to roughly 3.0 m/s at the occupant's body surface.

Draft air-flow variations, particularly in a frequency range from 0.3 to 5 Hz, cause significant adverse effects on the comfort of sedentary passengers.

Recommended flow rates for the car taken as a whole are much lower. Air circulation velocities of .08-.20 m/s have been recommended for high speed transportation. This will maintain a sense of freshness without creating undesirable drafts.

Most new rail vehicles also use the ventilation system to pressurize the interior to approximately 50 Pa; this helps prevent dust and noise from entering the vehicle. The pressure is created by exhausting less air through the nominal exhaust than is taken in through the fresh air intake. The rest of the air leaks out through other small openings around doors, etc. With nominal exhaust flow equal to about 80% of fresh air intake, the additional air creates a positive internal pressure that keeps out dust and noise. Of course, the precise balance of intake to nominal exhaust depends on the "leakiness" of the rest of the car. If the car is well sealed, positive pressure could still be maintained with exhaust equal to 90-98% of fresh air intake.

In a pressure-ventilated vehicle, open windows can completely upset air flow conditions to the discomfort of all but a few passengers. Consequently, opening windows are not provided on new designs of rolling stock, all the ventilating air being supplied by the pressure ventilating equipment. Some small windows or vents should be openable by staff in case of failure of the ventilation equipment.

Passengers are most comfortable when the mixture of recirculated air to fresh air is in the ratio of no more than 2.5-2.8 to 1. This allows for eight or nine air changes in the passenger compartment each hour for a typical passenger car with 30 cubic meters per minute of fresh air intake.

The total air circulation through each coach would be at a rate of 105-115 m^3/min when the outside temperature is within a range of 0-26 °C. The quantity of fresh air can fall (approximately linearly) to a minimum of 25 m^3/min at extreme temperatures beyond

-7.5 °C and 30 °C. Using the same ratio of fresh to recirculated air would result in total flow rates of 88 to 96 m^3/min under these conditions.

These figures are based on a requirement of about 30 m^3/hr of fresh air for each passenger. If a coach holds approximately 60 passengers, this means a total fresh air intake of 30 m^3/min. For an 80 passenger car, up to 40 m^3/min of fresh air would be required. For a double-deck design with 100 passengers, 50 m^3/min of fresh air would be necessary at all but extreme temperatures.

Microprocessor systems allow the simulation of climatic room parameters to avoid the overshoot of a typical "black and white control system." They allow the reliable integration of fresh air intake, humidity, and temperature control systems. In addition, the microprocessor offers diagnostic functions for installation, maintenance and service. This includes the use of a simple external minicomputer system to initialize the test routine and the interactive man-machine dialogue.

1.3. AUDITORY STIMULI

The limit of chronic noise causing damage to hearing is about 85 dB(A). Short-term exposure results in the auditory threshold being displaced for a limited period. Long term exposure results in hardness of hearing. This should be the maximum noise level for short durations under the train's noisiest conditions (eg. flushing the toilet while the train is running at high speed through a tunnel.)

The sonic pressure of speech must be 10 dB(A) higher than that of the disturbing noise to be intelligible. To improve the intelligibility of speech, interior noise should not exceed 70 dB(A).

The design criterion for noise is highly dependent on the passenger's activities at any one time. They can vary from 68 dB(A) for sleeping to 80 dB(A) during idle time. The high noise figures are unacceptable for long-distance passenger rail cars. These levels would interfere with sleeping, reading and conversation. Therefore, noise limit specifications should be based on 68 dB(A) for all-round comfort. At these levels and lower, added acoustic treatment may be required in coaches and sleeping cars to reduce transmission of sounds coming from the passengers.

The main source of noise produced by the train is the impact of the wheels on the rails. Wheels can be made quieter by various treatments of the wheels, rails, and railbed. But good sound insulation of the cars will remain essential.

Disk brakes are far superior to track brakes for both lower noise and smoother deceleration. They also produce more even wear on the wheels during braking. Track brakes often lock a wheel and produce a flat spot which increases the noise and vibration from that wheel, and leads to maintenance demands.

Another source of noise is the ventilation system. This is particularly the case with high air speed, small aperture air jets. The lower air speed and larger opening of the main vents make them quieter. If individual air jets are incorporated into coaches, and if they have a "white" spectrum, they may provide some beneficial masking noise for limiting the audible disturbance of conversations. This would reduce the need for added acoustic absorbing material in coaches, but the total noise level should still remain below 70 dB(A).

The psychological aspects of noise have received little attention compared to techniques for measuring physical characteristics such as amplitude and frequency. However, it is clear that noise can have other irritating properties besides being too loud. Squeaks and rattles in the train's equipment are annoying both because the noises themselves are unpleasant and because they can suggest to the passenger that the equipment is "unsound."

The patterning of noise stimuli is also very important. (This is also true with other changing external stimuli such as accelerations.) Regular and predictable patterns are preferred because we have the ability to habituate our orienting responses to regular stimuli. Under some conditions, certain regular noises are even relaxing. This is particularly true of low amplitude, low frequency sources with a repetition rate similar to that of a human heartbeat. This may account for the appeal of the "clickety-clack of the railroad track."

Other regular noises can be bothersome, however. Buzzing from electrical equipment, whistling from forced air outlets, or continual rattling or squeaking of seats, beds, etc. can be very irritating to passengers, especially if they must be exposed to it for hours or days.

Irregular noises can be even more irritating. Our ability to habituate to, or learn to ignore, auditory stimuli is hampered if the stimuli are loud, irregular, infrequent, and/or variable in sound qualities. Noise stimuli that consistently occur paired with other stimuli are even harder to learn to ignore. For example, brake noises are consistently associated with bodily sensations of deceleration. This makes the brake noises more obvious to the passenger.

Thus it is not sufficient to merely keep the average total noise level below some number like 68 dB(A). Each potential source of either periodic or irregular noise needs to be examined to determine its characteristics. The important characteristics include not only amplitude and component frequencies, but also sound quality, regularity, associations, and effects on the passengers' attention and activities.

1.4. VIBRATIONS

Comfort reactions to vibration depend on the positions of the passengers, their age and physical condition, their expectations concerning ride quality, and several other factors. There is some general agreement about the comfort of seated, physically fit, males in response to vertical, lateral, and fore-and-aft vibrations. Unfortunately, there has been little study of the effects of vibrations on other segments of the population, or on other postures and activities.

The ISO has standards for determining permissible vibration levels for passenger comfort and activity - ISO 2631. But these standards are not totally satisfactory. Short-term amendments and a long-term revision of this standard are in progress, as discussed in a recent report by Allen (1982). But much of the necessary research has not yet been done. It is only recently that vibration exposure times of up to 8 hours have been considered in the standard. Exposure times of up to six days on a train demand that vibration to the passengers be reduced as much as possible. The fact that a significant portion of the train-riding public may be elderly people or those with physical disabilities is another reason for having conservative vibration limits.

There have apparently been no vibration studies involving people trying to sleep. But vibrations can interfere with falling asleep, drinking, writing, reading and many other activities at levels below that which causes physical discomfort. The same is true with accelerations, discussed below. In fact, the ISO frequency weighting curves can be considered to describe accelerations at low frequencies and vibrations at higher frequencies.

1.5. ACCELERATIONS

Discomfort depends not only on the magnitude of accelerations but also on the rate of change in accelerations (jerk). Ride quality considerations for seated passengers require that longitudinal acceleration and jerk due to starting and braking be limited to 0.2g and 0.2g/sec respectively. These levels would cause problems for walking or standing passengers or those who are changing locations (eg. getting out of their berth.) Therefore, these rates should serve as maximum values. During normal running, accelerations and decelerations should be less than 0.1g. (One g equals the force of gravity, 9.8 m/sec/sec, so 0.1g is about 1 meter/sec/sec.) Lateral acceleration and jerk in curve negotiation should be limited to 0.1 g and 0.2 g/s respectively.

The primary cause of motion sickness is vertical accelerations. Compared to boats and airplanes, train passenger compartments do not experience appreciable vertical accelerations. Motion sickness is rarely a problem on trains. Lateral accelerations are a problem, however. They result from lateral inconsistencies in the track alignment. The wheels "hunt" for the proper location over the track and these hunting oscillations are transmitted to the passenger compartment. Since passenger cars are usually built all the way out to the clearance line, hard stops are used in the lateral suspension to keep the vehicle within the lateral clearance envelope. These stops increase the "jerk" of the lateral accelerations. The design of lateral suspension equipment should be improved so as to optimally damp these hunting oscillations. Ideally, the lateral track defects should also be corrected.

These lateral accelerations can interfere with the passengers' walking, reading, sleeping, and writing, as well as any other activities that require fine motor control. Human abilities did not develop in a vibrating, accelerating environment. Our internal movement control systems work best in a stable environment. If we are standing or walking we can generally regain our balance if it is upset by a lateral force transmitted through the floor. But some people have more difficulties in this regard. Balance problems are common among elderly persons, and people with physical or mental handicaps. Drugs, alcohol, state of wakefulness, and other factors can also affect our ability to walk or maneuver in an unsteady environment.

The fact that, from the passenger's point of view, the accelerations are unpredictable adds to the difficulty. Passengers can usually stop walking, writing, or whatever, fairly quickly if they start to experience accelerations. However, the initial movement may cause them to lose their balance, make a scrawl on the form they're filling out, or spill the juice that they are pouring. If the places which cause large lateral acceleration are infrequent and predictable, a brief and mild warning tone could alert passengers to brace themselves if moving, or stop momentarily if writing or working. If large lateral accelerations are too frequent, or too variable, such a tone would probably be more of an annoyance than a help.

1.6. LIGHTING

Lighting requirements on long distance trains vary depending on the passenger activities that the lighting is required to support. Under normal night conditions, the minimum lighting intensity in passenger car vestibules, aisles, toilet rooms, bedrooms, and passageways for passenger safety should be approximately 50 lux when measured at floor level. If stairs, steps, headway obstructions, or tripping hazards are present they should be illuminated with at least 200 lux. Food preparation areas, passenger reading areas, and passengers' faces in toilet mirrors also require lighting with high intensity. For instance, food preparation areas should have a lighting intensity of 400 lux measured at the working surface.

The following are some criteria for good lighting design:

1. All spaces (entry, transitional areas, seating spaces) should be properly composed in a clear hierarchy of importance. Light should be directed where it's needed. In dining cars, for example, the primary targets of the lighting should be the table tops and the floor.
2. Lighting should provide spatial clarity. It should not create incorrect impressions of distances or sizes.
3. Lighting systems should be cost effective (including initial costs, cleaning, maintenance and bulb replacement needs.)
4. The quantity of lighting must be appropriate for the types of activity that passengers want to do.
5. The lighting should fully utilize the potential of daylight, where available.
6. The system of lighting should be energy efficient.
7. The lighting should be designed and positioned to minimize glare, reflections, pools of darkness, and transmission of noise or heat to nearby passengers.

Two lighting environments - daytime and nighttime - must be provided in a long-distance railway car. A general illuminance of 160 lux should be provided for daytime and 50 lux for nighttime. Trains also require emergency lighting systems. These should utilize some portion of the regular lighting system that can be powered by batteries. Open cars should have fluorescent luminaires down the centre of the coach or on the passenger luggage racks, as well as local lighting for passenger reading.

An illuminance of 750 lux should be provided for reading by local lighting.

Lighting for a task should not be placed in the 0-50 degree position, relative to the passenger's forward line of sight, as it will produce glare and passenger discomfort. However, since passengers on a long train trip may adopt all sorts of postures for reading or working, the reading lights should have adjustable aim. They should be positioned above and slightly ahead of the passenger so that shadows are not cast on the reading material by the reader. Manual adjustment should permit the light to be aimed at any point along an arc between the two armrests (or at least in a line from left to right.) The reading lights need some shrouding to keep them from glaring in the eyes of the passengers in adjoining rows who may be looking in that direction.

High intensity light is required for reading. If it has typical ceiling or overhead rack mounting, an incandescent bulb and lens combination is required. The bulb should be bayonet mounted to ease replacement and reduce loosening from vibration and shock. Bayonet mounting also permits the light filament to be aligned consistently to produce a correctly oriented light field. The bulb and lens should create a consistently illuminated field about 40cm wide and 30cm high (given that the aim can be adjusted.)

The light switch can be located in the armrest, or other easily reached place. The adjustment of the aim will require standing, or else passengers will bump their heads on the lights. Shorter persons may have to stand on their seat to change the aim of their reading light. It is not an adjustment that passengers will need to make frequently, but it permits both various postures for reading and some feeling of control of personal environment. Both of these features can significantly enhance the enjoyment of a long train ride. This kind of aim control is essential if passengers are to be able to read comfortably for several hours per day on a multi-day journey.

In other applications, flourescent lights are preferred to incandescent in terms of light quality, bulb life, and energy efficiency. They should be used wherever possible in passenger areas. Fluorescent lamps with a smaller diameter than the common household and industrial size should be used. These newer tubes are about 25 mm diameter and fit more easily into tight spaces. Fluorescent lamps should operate on an AC power supply in the 400 hertz to 25 kilohertz range. High frequency operation removes any flicker and makes dimming of flourescent lights practical.

Tables and food trays should be illuminated to a level greater than that of the general surroundings, and no lower than 220 lux. Improvement of the effect of lighting on the ease of reading low contrast or fine print material has been found up to 2000 lux. Maximum performance for a lighting system occurs at colour temperatures between 3,300 and 4,300 K for standard black and white as well as coloured tasks. The apparent skin colour of the passengers is also a consideration. Cooler colours may tend to make passengers look slightly blue, green, or gray and should be avoided. Warmer colours create a more pleasing visual environment. Also, it has been found that people work significantly more quickly under fluorescent lighting than tungsten. Therefore, fluorescent lighting may also be more suitable for local lighting for cooking, serving, and dining areas. Fluorescent lighting for reading might also have some advantages but it does not provide a sufficiently concentrated light source for individual reading lights that would not interfere with others.

The recommended level of illumination for conversation, relaxation and entertainment is 110 lux, for dining 165 lux, for reading and writing 750 lux, and for walking in aisles in the daytime 150 lux.

Both blinds and curtains should be provided in rooms and roomettes to allow passengers to lower or increase lighting levels when they wish. Opaque blinds should be able to shut out all outside light, while curtains should permit significant amounts of light to enter but maintain the visual privacy of the sleeping compartments. In seating areas, blinds do not need to be entirely opaque, but they should be able to reduce the glare from sunlight. Curtains are not needed in seating areas.

Curtains are also not required in dining or lounge cars, but they do create a warmer and more "homey" atmosphere. However, they serve a more decorative purpose here and blinds should be used for controlling light coming in from the outside. The curtains can remain at the sides of the window and do not need to be the full width of the window. If these areas are to also be used for meetings, conferences, or entertainment, the outside light should be able to be totally blocked by the blinds.

Washrooms require frosted or patterned glass to maintain visual privacy. No curtains or blinds are necessary in washrooms. Lighting in washrooms should illuminate all of the symbols, signs and fixtures so that their meaning and location are clear. Additional lighting should be directed toward the face of someone looking in the mirror. The illumination should be about 300 lux at the plane of the passenger's face. The mirror lighting in sleeping compartments should be operated by a separate switch. This permits the bright light over the mirror to be turned off when not in use, to reduce unwanted glare.

Only the rooms and roomettes should permit the lights to be totally turned off. Many people prefer total darkness for sleeping. However, a small night light should also be provided to illuminate the compartment slightly for those who want some light. It should be bright enough to permit safe movement if someone needs to get up in the night, but it should not shine on the berths or beds.

Reading lights in the rooms and roomettes are also appreciated by many passengers. Ideally, they should be usable both for passengers sitting in their seats and for those wishing to read in bed. In accommodations with more than one occupant, other passengers should be able to sleep without someone's reading light disturbing them.

On most passenger rail cars with air conditioning, the windows are tinted to reduce solar heat input in the summer. However, this also reduces visibility out of the window, especially at night. A new option is available that reduces infrared transmission without effects on the visible spectrum. It is a "solar film" that relies on a thin layer which selectively absorbs infrared wavelengths by inducing resonance.

In summary, lighting requires a careful analysis of the users' potential needs for each location in the train. Different light levels are necessary depending on possible activities and time of day. The light required for one passenger's activity should not impinge on another passenger in terms of glare or unwanted light. Blinds and curtains can be used to control amount of daylight and visual privacy. Their characteristics and ideal functions differ between the different windowed areas on the train.

1.7. SIGNS AND INFORMATION

The information needs of first-time or occasional travellers are somewhat different than those of passengers who take the train frequently. There are three basic sorts of information that passengers may need or want:

- locations - where to find their seat, luggage storage, the washroom, the dining car, the hand soap, etc., also exterior locations such as passing points of interest during the day, or the train's progress along the route.
- operations - how to flush the toilet, how to lock the door, the railway's liability for lost or stolen articles, rules and regulations, emergency procedures, identifying or summoning staff, etc.
- schedules - arrival times, when to go to the dining car for breakfast, when the beds are made, expected duration of delays, etc.

It is hard to overestimate the information needs of first-time passengers or those who use the train very infrequently (eg. once every few years.) These passengers may be completely unfamiliar with almost all aspects of the train, from choosing a seat to finding the lounge car. Although much of the information is not critical for getting to your destination, passengers prefer to know what's going on.

For example, the procedures for checking tickets is rather mysterious. If passengers do not know when the train staff member is coming to check their tickets, they may be anxious about being missed. They can find themselves in a conflict about whether or not to leave their seats to go to the washroom or bar car because they have no idea what will happen if the conductor does not find the seat occupied when the tickets are eventually checked. If the tickets are never checked, people tend to feel resentful, thinking that they did not need to buy a ticket or that others may be riding for free while they have paid.

Decisions on how best to present various sorts of information to passengers depends on the type of information, how frequently it is required, how frequently it changes, how critical it is to safety, comfort, or trip satisfaction, and how the passengers can most easily and correctly process the information.

In terms of schedules, passengers usually want information concerning their own train, not the whole system. Some information about connections might be useful, particularly if your connecting train is waiting for the delayed arrival of the train you are riding. An on-board information display system could provide a variety of information in combination with a public address system to announce upcoming stops, points of interest, emergency information or schedule updates. A clock in an on-board computer connected to the visual display could be used to change the time where required in messages, or the system could be driven by a central computer. Special messages could be entered by a keyboard on the train. Each message should appear for about three times its required reading time.

This sort of information display would not be required in every location on the train (eg. in every washroom, roomette, and vestibule.) Depending on the type of display it might suffice to have just one for each car. If a large VDU, LED matrix, or flip-dot matrix display is used, it should be in a consistent location in each car, such as overhead to the right of the front door. This would allow the passengers who want information to find it easily. If smaller versions of the LED matrix display (sometimes called programmable annunciators) are used, it would be better to provide one for every few rows of seats. This would make information available to all of the passengers at their seats. For any of these electronic displays there should be a distinctive audio and visual cue to indicate important information.

Information describing amenities, facilities and services on the train could be presented on an electronic display but locations and operations information is more effective if it is spatially associated with the referent. Thus the sign that directs passengers to the washroom should be near or oriented to the washroom. The information on flushing the toilet should point the user to the control lever. Various candidate graphic symbols for use on the train should be tested with a representative sample of patrons to determine legibility distance, comprehension and preference.

Behavioural Team feel that, wherever practical, French/English text should accompany graphics on signs to remove any ambiguities. For some sorts of information, only text messages seem practical. We have yet to come up with a good pictograph for "Do not flush the toilet while the train is in the station."

An interactive computer information system might be put to good use on the train for information and entertainment. A small microcomputer or dedicated teletext system could provide all of the relatively constant information on train operations and rules, as well as entertainment features. With the long run in mind, train companies should make provisions for later inclusion of an "Electronic Carrel" in some train locations. This would include modem and terminal facilities for connecting to mainframe computers or information services located off the train. This would allow a broader range of communications and information transmission than a mere telephone. In addition, the terminal could be part of a microcomputer that can carry on some functions (games, train information, etc.) locally.

Things like rules and guidelines for appropriate behaviour on the train are best noticed and understood if they are presented in some entertaining format. A poster with cartoon representations, a computer game or quiz, a brief and clever video presentation, or a magazine with both train information and general interest features could attract passenger attention and transmit the necessary information. Small handouts with lists of rules and explanations are generally ignored by all but the most obsessive-compulsive people.

Public address systems are common on newer trains. They are generally used for announcing train departures and arrivals. Taped announcements made by a professional "voice" such as an announcer or actor create a better impression than announcements read by train crew lacking voice and public speaking training. The public address system could also be used for presenting a variety of information to passengers. If train crew are expected to make announcements to the passengers, they should have some appropriate training.

Music should only be presented to passengers who want it. This means some system of earphones. Train passengers generally do not want canned music piped in over the loudspeaker system.

1.8. OTHER VISUAL STIMULI

To allow passengers a good view of the scenery, the placement of windows should be designed taking the proposed seat pitches into account. Windows should be aligned with the seats for ease of viewing out.

The main conditions for achieving a satisfactory visual environment are:

1. clean windows with a good view out.
2. a visually pleasing interior environment.
3. a choice of visually private and visually public spaces.

All three of these conditions require input at the design stage. The first two also have maintenance implications.

The windows should be as large as possible to permit a maximum view angle. However, there is little point in extending the windows downward. The scenery viewed through the lower part of the window is moving too fast to be seen clearly. Even in the upper level of a double-deck car there would be little or no positive value in extending the windows lower. For many people, a window that extends below their centre of gravity causes feelings of insecurity and discomfort. But it would be good to extend the upper limits of the windows as much as possible. In the upper level of double-deck cars the windows could extend into the roof line.

1.9. SPACE

The amount of space provided and the specific layout of that space are very important to passenger comfort. Generally, people prefer spaces that are larger than those which are economical on trains. Space is at a premium, although less so than in airplanes or some other modes. The width, height, and length of individual cars are constrained by various clearance and stability requirements. The combination of different power and passenger cars making the train (or consist) is constrained by various other factors ranging from station platform length to power requirements for desired speed. All of these factors, in turn, limit the space available. The space must be designed for optimizing the necessary and desired behaviours and states of the passengers. More space per passenger is required on longer trips since a wider range of behaviours and states must be accommodated.

The different candidate interior layouts should be evaluated with a mock-up. The mock-up should explore dimensions such as aisle width, roomette layout, washroom size, etc., and other design features such as colours, windows, and the like. Mock-up seats can be used to assess dimensions such as arm-rest width, tray design, and seat width. This will allow optimizing the division of the design envelope into the necessary components. The discussion of spaces in the next sections consists of some general guidelines that will require fine tuning. Decisions should be based on testing with both representative and exceptional passengers and mock-ups that can be altered easily to test alternatives.

1.9.1. PUBLIC SPACES

For a maximum density situation such as snack bar queues, areas of .6 square meters per person will be tolerated for short periods. However, if passengers typically are carrying something (eg. a large travel bag, purse, camera, a food tray, or a cup of hot coffee) about .9 square meters per person is necessary. The shape of the typical passenger area is also affected by carrying objects. This impacts on the design of aisles, doorways, etc. Obviously these queuing and passage spaces cannot be large enough for maximum comfort under all conditions. The minimal requirements may be set by factors such as wheelchair access, or the space needed for two large persons without bags to pass each other without stepping out of the aisle.

Lounges and snack bars should provide a variety of seating arrangements. This permits people who want or do not want social interaction with other passengers to choose a location that suits their goals. The precise mix of eating and drinking spaces depends also on other factors, such as type of meal service.

Some proposed clearance dimensions for various public spaces are listed below. Some of these dimensions may need to be compromised to fit in the train's design envelope.

head clearance (for 95%)	1,980 mm
aisle width in coaches	
at floor	750 mm
at 0.5 m	780 mm
at 1 m	800 mm
aisles between tables (double circulation)	400 mm
between wall & table (movable chairs)	900 mm
between wall & table (rotating seats)	550 mm

More detailed information concerning anthropometric data can be found in Panero and Zelnik (1979), Dreyfus and Associates (1974, 1981a, 1981b), and Behavioural Team's many public spaces reports.

1.9.2. ACCOMMODATION SPACES

Most passengers spend the vast majority of the time on a long train trip in their own accommodation space. They venture into public spaces to use the washroom, stretch their legs, or get something to eat. But their own seat or compartment is the place that must be comfortable for the long stretches of time in between these forays.

1.9.2.1 SEATING

The amount of space provided to the passenger is very important to his comfort. For example, the LRC "high density coach" was designed for a seat pitch of 100 cm and the "day-niter coach" around 145 cm. Airplanes might be as close as 76 cm in pitch.

Demographic data suggest that further investigations be made into developing a greater variety of seat configurations. For example, the elderly require different seat sizes than the normal adult population. Elderly males 65-74 years are 6.1 cm shorter and .45 kg heavier than younger male adults; elderly females are 5 cm shorter and 6.4 kg heavier than younger female adults. Ideally, the dimensions of some seats should be adjustable to accommodate elderly passengers. For example, headrests should be able to be raised or lowered.

One of the main seating problems for short passengers comes from an inability to rest their feet flat on the floor. This puts excessive pressure on the arteries in back of the legs. There is no ideal solution to the problem of different seat size requirements. Adjustable height seats are more expensive to design, build, and maintain than fixed height seats. Having different fixed seat heights within a car will never result in everyone having exactly the right size seat. But when the cars are not fully occupied, a few shorter seats in each car should result in increasing the "good" matches more than the "bad" ones.

A better solution involves the use of small footstools or footrests. These allow short people to sit comfortably in taller chairs. Separate footstools have the advantage of being totally adjustable in terms of position, and useful by almost everyone. They would have the disadvantage of being popular souvenirs. However, they could be rented or sold to the passengers wanting one. Connecting the footstools by a cable or chain would create an unacceptable tripping hazard. Connecting footrests to the seat ahead constrains the seat layout. In addition, it is nearly impossible to isolate the forces put on the footrest by the passenger from affecting the passenger in front. Footrests that fold out from under your own seat can interfere with stowing things under the seat. In addition, they are usually too close to be used by tall persons.

Disabled passengers in wheelchairs do not want to be isolated from the rest of the passengers. A wheelchair tie-down system will greatly improve accessibility for the handicapped and will be best liked if wheelchair users could sit among ambulatory travelers. In many cases, it is better to have a small wheeled carrier so an attendant can move a handicapped passenger about on the train. Many handicapped persons can then sit in regular seats the rest of the time.

For optimum comfort the seat should be 560 mm wide, 430 mm tall from the base to the seat, 105 degrees from the back to the seat, and the seat should be tilted back 7 degrees. For comfortable seating the width of a double seat should be about 1150 mm.

There are numerous seat designs which merit consideration. Decisions on other factors, such as luggage storage, seating configuration, and placement of other fixtures, all affect the choice of seat design. Different seat designs would be appropriate for different layouts. For example, if most of the seats are back to back with tables between facing rows and luggage storage between seat backs, fixed seat bases are required. Reclining involves moving the seat bottom forward rather than moving the back backward. If the seats can be turned to face either direction, reading lights require broader aiming capability, but the seats can be reclined farther if there is not another seat back behind you.

To some extent, the ideal seat from the passenger's point of view is incompatible with maximum seating density. The ideal seat for a journey of several days and nights could be oriented in any direction in the car, and could be adjusted to any angle or seat height. However, too much space would be required for full rotation and reclining. The balance that is chosen should reflect some good compromise between passenger preferences and behaviours and the economics of seating density.

1.9.2.2 SLEEPING COMPARTMENTS

Small sleeping compartments are problematic because of ergonomic considerations such as head clearance, space for changing clothes, and access to upper berths, and because of psychological factors such as limited privacy and feelings of claustrophobia. To optimize space in small sleeping compartments, there should be a separate washroom/dressing room for each 12 to 18 sleeping compartments in the car.

The sleeping compartments should be able to be closed to stop visual, odour, and sound transmission. They should have lighting, temperature, and airflow controls. Lighting should include ambient, reading, and night lights. Music should also be provided, again under passenger control. Windows adjacent to sleeping compartments should be designed so that all passengers can get some view to the outside without adopting unusual postures.

In terms of maximum utilization of space, the same area that contains sleeping compartments at night should provide seating areas for those passengers during the day. However, this is a difficult design task, especially if the compartments are designed to be completely enclosed.

The alternative for maximum density sleeping accommodations is a shared sleeping room like the couchettes used in Europe. However, more thorough study is need to determine if this arrangement would be acceptable to enough Canadian passengers. Another alternative is to have sleeping compartment cars only on the train at night, with coach seats for the passengers during the day. However, this requires more cars and changes in the consist.

The optimum length for beds is about 198cm. However, if there are hard walls at each end of the bed, more space is required for taller passengers. The width for a single passenger's bed should be at least 90 cm. A slightly wider bed (say 100 cm) could accommodate an adult and a small child. At least a 115 cm width is required for two adults in the same bed.

1.9.2.3. ROOMS AND ROOMETTES

Rooms and roomettes on the train are the most expensive sort of accommodation because they are more expensive to construct, they take up more space for each passenger, and they have greater crew and maintenance requirements.

If rooms have either two or four berths each arranged on an angle, this permits more full-length beds to be placed in the limited space available. The resulting recesses in the outside corridor permit passengers to pass each other more easily. Design of rooms might also include shared showers for each car with a toilet and washbasin in each room. Limited refreshment facilities should be provided, even if it is merely a few drink and snack vending machines. Special efforts are required to reduce noise and vibration and to retard fire and prevent toxic smoke or fumes. It is common to offer different room accommodations within a single car.

Double-deck cars are particularly amenable to effective room and roomette design. Passengers in rooms do not move about the train as much as passengers whose accommodation space is limited to a seat. Several construction features, such as plumbing to each room, are also facilitated by double-deck designs.

1.9.2.4. MATERIALS AND FABRICS IN ACCOMMODATION SPACES

Some sort of fabric or covering is in contact with passengers in most areas of the train. Modern fabric technology allows specification of textiles which are functional, attractive, and comfortable. There are many functional demands, including fire and smoke retardancy, insulating properties, and maintenance requirements. Comfort features depend on both the fibre and the processing of the textile.

For floor coverings:

1. Carpets provide a safe walking surface that is easier to keep clean-looking than a hard floor.
2. Carpeting helps in sound and thermal insulation of the passenger compartment.
3. Colour, lustre, pattern and other features of the carpet can improve the appearance of the accommodation space.
4. On the negative side, carpets can get easily stained and cause odors, and can generate static electricity.

The exact carpet specifications depend on the location. More durable, resin impregnated carpet is required for entranceways where mud and snow are tracked onto the train. Train carpets must be long wearing and easy to maintain, flame resistant, and must not produce toxic fumes in a fire. Bulk continuous filament (BCF) yarns are most suitable for heavy traffic areas. Nylon or nylon blends have advantages over other fibres in terms of most properties but are worse in terms of static electricity. An acceptable level of static generation is 3KV at 20% relative humidity (RH) and 20 °C. There are treatments to the fibres (carbon core, metallic fibres) and to the backing which can reduce static.

Carpet colouring can be used to indicate pathways, designated areas, changes in floor slope (which may be useful in bi-level designs), and other information functions.

The physical features determining "hand" or feel of fabric are listed along with the subjective quality they determine:

*flexual rigidity, bending modulus hardness, thickness, density compression modulus	softness
*surface friction, cover factor	smoothness
*crease resistance modulus	levelness
*water permeability	thermal comfort

Fabrics for different surfaces require different characteristics. For example, bedsheets need to be soft and smooth, while curtains need to repel dust and resist bleaching by the sun.

In train sleeping accommodation, it is better to have multiple layers of blankets which can together provide the maximum necessary insulation rather than one blanket or duvet which would sometimes be too hot. As in other issues, adjustability and choice lead to passenger happiness.

Some recent developments which may be relevant to fabric choices for use in passenger rail accommodation are:

*sheets made from fibres with a polyester core covered in cotton.

*textile wall coverings containing flame resistant modacrylic fibres.

*flame resistant polyester for curtains.

2. BEHAVIOURAL VARIABLES

2.1. BOARDING AND LEAVING THE TRAIN

Although boarding and alighting account for only a small portion of the time on a long train trip, these activities are the source of many problems. The main sources of discomfort, problems, and hazards are:

a. the need to climb up steps to get into the train
b. the loose step on the platform
c. large amounts of carry-on luggage
d. insufficient assistance from rail personnel
e. inadequate hand rails
f. persons entering and leaving the train at the same time.

New designs could avoid most of these problems through level boarding. This generally requires that the platform be built up to the level of the cars' floors, or that the cars be built with much lower floors. The issue of raised platforms is a complicated one that interacts with questions concerning level of service to small stations and maximum train length. Consequently, some boarding with steps is likely to continue, especially at the smaller stations. But level boarding at all major stations should be part of long-term service plans.

Level boarding, in combination with clear signs and information about which car is yours, could eliminate the need for train crew on the outside of the train to assist passengers. Their help could then be concentrated on the inside to show passengers their seat or compartment, assist the elderly or handicapped with putting their luggage into appropriate storage places, answer questions, etc.

Doorways should be 1250 mm for a two lane entry and exit system. This allows passengers to carry luggage in front of them but not beside them. 1950 mm is a satisfactory door height in view of the downward steps on leaving the vehicle. For eventual level boarding, however, the doorways should be made at least 2050 mm.

A retractable step with a height of 185 mm improves the ease of boarding and alighting for both young and elderly passengers. On trains, a retractable step fixed to the car provides more secure footing than the typical stool placed on the platform. It should not protrude from the side of the car when it is running or in a station with elevated platforms. Special care must be taken in the design of a folding lower step to keep winter snow accumulations from blocking its operation.

Preferred handhold dimensions for elderly people for boarding and alighting are:

*vertical and sloping portions, with the sloping rail at a 1 m height
*an oval section rail 32mm x 18mm
*a surface finish which minimizes slipping for axial forces
*at least 70 mm clearance from the handrail mounting surface.

A thickness of the step of 20-40 mm and a step height of 340 mm above the platform has proved satisfactory. The overhang angle of 8-10 degrees chosen to given gradient clearance at the front and rear has proven practical. The relative boarding height of the first step is as a rule 200 mm; this means that the minimum floor height 340 mm above platform level is satisfactory. The most favourable step depth is 320 mm.

However, Behavioural Team firmly believe that only level boarding (a high platform or a low floor) can offer every advantage as regards convenience, speed and safety when passengers are boarding and alighting.

2.2. LOCATING YOUR "TERRITORY" ON THE TRAIN

The initial choice of territory on the train takes place when you order your ticket. The person selling the ticket or making the reservation should explain about the different sorts of accommodation available on the train and provide some information about the location of one's territory on the train. In addition, the train and ticket should be clearly marked to indicate the general location of the passenger. In the case of sleeping accommodations and reserved seats, it is a matter of locating one's assigned territory. If seats are not reserved, passengers are also required to make some choice of territory.

If people have to sit among strangers, they most often choose their location on the basis of least density. The preferences of pairs are based on the ability to sit side by side, also with some tendency to less crowded areas. Groups of three or more tend to choose seats where they can converse more easily.

However, seat choices on the train are influenced by other factors such as windows, no smoking areas, or proximity to the bar car. Also, on a train, some passengers will want social interaction with strangers. They will choose seats adjacent to others.

The main design questions relate to:
- groupings of seats,
- orientation of seats,
- ability to turn seats around,
- use of tables between rows of facing seats,
- variety of seat choices available, and
- requirements of different travel groups.

These relate to other issues, such as location of luggage storage, need for snack and drink trays, 1st versus 2nd class seating, etc. For example, in the typical 1st class seating arrangement of two seats on one side of the aisle and one seat on the other side, there are proportionately more seats for people who wish to sit alone than in the 2+2 arrangement typical of 2nd class coaches. It is not known, however, what proportion of 1st class passengers want to sit alone on a long trip.

Behavioural Team advocate as much freedom of choice as possible for passengers. This means that either the seats should permit rotating and placement of tables between rows, or there should be some seats facing each other and some facing walls or seat backs. A fixed arrangement is easier in terms of operations and maintenance. It requires some prior knowledge about passenger preferences to optimize the arrangement in terms of the number and location of individual versus paired versus group seating. However, other considerations, such as luggage storage between seat backs, may result in less individual seating than may be preferred by persons wishing maximum isolation from other passengers.

2.3. HANDLING LUGGAGE

Train passengers carry more luggage onto the vehicle than do passengers on buses or airplanes. Access to their luggage is also more important on long train journeys since several days of uninterrupted travel can be involved.

On trains, luggage storage between the backs of seat rows facing in opposite directions has some advantages because heavy items can be near the floor level and close to the passenger without getting in the way. By "distributing" the luggage rack through the car, seat density can be lowered. This helps solve the paradox of how to have speech privacy and low noise levels - the riders are further apart.

Overhead racks are a problem because of the possibility (at least in passengers' imaginations) of falling bags. Also the rack depth may be too small for the largest bags, while smaller bags may disappear from sight and be hard to retrieve. Train crew should expect to assist some passengers in stowing their bags, especially if only overhead storage is available. Minor handicaps that may not be obvious to an observer (such as heart trouble or arthritis) can result in the need for help in placing luggage in its storage location or retrieving it.

The best information on the luggage of train passengers indicates that the following dimensions should be used for design purposes:

Dimension	Mean	Standard Deviation
length	51 cm	14 cm
width	18 cm	5 cm
height	37 cm	9 cm
weight	8.4 kg	5.1 kg
density	230 kg/m^3	89 kg/m^3

These dimensions may be helpful in designing luggage racks and storage areas. Passengers prefer to have their luggage nearby and accessible. Luggage racks in vestibules are seldom used because they do not provide enough security. If luggage racks for large suitcases are used, they should be in the main passenger compartment, or separated by a see-through partition. Special racks will be required in some coaches for skis and other bulky sports equipment. These racks need not be in the passenger compartment. In sleeping cars, in particular, long overhead racks for skis can be placed in the corridor.

Provisions should be retained for people who wish to check some or all of their luggage to their destination. The limits on accessibility to checked bags should be explained when information on checking is requested, and again when the bags are checked-in at the station. If the bags might not arrive on the same train as the passenger, this should also be explained in advance.

2.4. ACTIVITIES IN THE ACCOMMODATION SPACE

2.4.1. SITTING

Sitting does not involve a great variety of behaviours, but some of them are sources of problems. Train passengers spend most of their time in their seats. They also get up frequently to walk around, go to the washroom, visit the lounge car, etc. For this reason, it is important that they have enough room to stretch out and get up easily without knocking their heads on a luggage rack or stumbling over other passengers.

Supports and handholds are important when entering or, especially, leaving a seat. Armrests and seatbacks are most commonly used by passengers. Difficulties are greatest when a passenger at a window seat must get past another passenger sitting in the aisle. Proposed seat designs should be evaluated by users most likely to have problems, to assess ease of getting into and out of the seats.

Once the passenger is in his or her seat, sitting behaviour consists mainly of postural adjustments to relieve pressure or tension, or to engage in some other behaviour such as looking out the window or reading. As mentioned previously, it is important for comfort to be able to rest one's feet on something. Not only does this decrease the pressure on the back of the leg, it permits the legs to be used more effectively in postural adjustments. Armrests and seatbacks are also used as supports in these movements.

2.4.2. RECLINING

The amount of reclining possible in train seats depends on several factors. Maximum reclining for the largest number of passengers can be achieved in open coach designs with rows of seats all facing the same direction. For optimum comfort when reclining, the reclined seat should not interfere with the legs of the passenger sitting directly behind. Leg or calf rests are also important for comfort while reclining. Although it is important to rest the feet while sitting up, resting only one's feet while reclining puts undue stress on the knees. The proper integration of reclining mechanism, footrest, and calf rest depends on the seat design.

When the train is not fully occupied, some passengers can lie down across two seats if the armrest can be folded away. A 3+1 layout of seats would make this more comfortable, but it is not wise to design based on 30% occupancy of coaches.

2.4.3. READING

Reading is a very popular activity on long-distance trains. Not only does it provide some education and/or entertainment, reading is also important in privacy regulation. Most people will not continue talking to you for too long if you ignore them. Reading material provides a polite excuse for ignoring someone sitting right next to you.

The type of induced movements does not readily lead to motion sickness while reading on trains. But some of the vibrations may make reading more difficult. Passenger activities are significantly affected negatively by rotational motions of the train in the 1-20 Hz frequency range. Proper reading lights, as discussed above, are important for facilitating reading.

Most passengers bring their own reading material; however some should be available on the train. An on-board magazine can provide entertainment, information, and advertising revenue. Other magazines should also be provided, whether they are sold at the snack bar or placed in durable covers and loaned out.

The ability to engage in such behaviours as reading, writing, eating, drinking, and looking out the window contributes to passengers' feeling of well-being and feeling of satisfaction during their trip.

2.4.4. TALKING AND SOCIAL INTERACTIONS

A responsive environment should be designed to permit easy alteration between a state of togetherness and a state of isolation. A face-to-face seating arrangement across a table facilitates interactions. Passengers sitting alongside one another are next most likely to talk together, followed by passengers on opposite sides of the aisle. Those facing front-to-back are less likely to converse. Train passengers are very unlikely to converse with other passengers who are more than 2 m away, unless they approach closer first.

Passengers should have some choice of seats to allow for privacy regulation or social contact. Other areas such as dining or lounge cars can serve either to find new people to talk to, or avoid the people sitting near you in the coach.

As described above, the noise levels have to be low enough for speech to be easily understood by those nearby, around 68Db A. At this noise level, additional acoustic insulation is required to keep the conversation and noises from travelling too far.

2.4.5. PLAYING GAMES

Video games have been well received by passengers on some other modes and deserve consideration by rail management. They can provide for passenger entertainment, relieve tension and boredom, and facilitate privacy regulation. New liquid crystal display games can be made to fit in an eating tray. Such games could be a minor source of revenue, or at least pay for themselves.

Other games such as cards, checkers, etc. can also be played on the train, and inexpensive cards or board games should be sold from the snack bar. Many of the more complicated board games, such as Monopoly, Scrabble, or Trivial Pursuits, would require a table to play. Usually only families or other large travel groups engage in playing games for more than two players. For almost all travel groups, reading is a more important activity and its support should take precedence.

2.4.6. SIGHTSEEING

Viewing is a very popular passenger activity on trains. For this reason, train windows should be cleaned regularly. Other design considerations relevant to sightseeing have been described in the preceding sections on lighting and other visual stimuli.

2.4.7. WORK

The ability to work is closely related to passenger satisfaction on long distance train journeys. Work such as reading and writing are a main dimension of passenger satisfaction and comfort. For this reason, rail management should provide reading and writing support on trains since these are highly valued passenger activities. Travel by train can be contrasted to air travel by allowing business travellers true opportunity to accomplish substantial work.

In most cases, this merely requires a table or tray, sufficient light, and limited acceleration, vibration and noise. As microcomputers become more common work tools, however, provisions for using them on trains (and for defending from their RFI) must be considered.

2.4.8. SELF CARE

Self care involves eating, drinking, grooming and hygiene, and unpacking/repacking personal effects. For eating and drinking at one's seat, foldaway trays on the seats should be provided. It is important to have enough space between seats that eating and drinking can be done comfortably without spilling. For personal hygiene (i.e. washing, shaving), basins should be provided in each roomette. Luggage can be stored in a closet in the roomette. Room should be provided for at least two pieces of luggage per person.

2.4.9. CARE OF TRAVELLERS WITH SPECIAL NEEDS

There are a variety of special needs experienced by railway travellers. They may be related to age (either young or old), mental or physical disability, temporary infirmity, or characteristics of the travel group.

For the elderly who have failing eyesight, there should be transitional lighting arrangements between one area with too much light and other areas with too little. A continuous overhead moderate lighting arrangement is needed; extremes in contrast need to be reduced. Signs should be illuminated so they can be seen clearly by elderly passengers.

To facilitate accessibility by handicapped passengers, 1500 mm wide access doors for wheelchairs should be provided on rail cars designed to accommodate the disabled. The corridor should be 850 mm wide, and the toilet door 1000 mm wide to allow wheelchair access. If level boarding is not possible, lift platforms should be installed which can raise a wheelchair or luggage from ground level. The luggage area should be equipped with oxygen apparatus and a stretcher.

Trains in Canada do not travel at altitudes greater than about 1700 m. Therefore, oxygen should not be necessary for any passengers with normal respiratory functioning. However, some persons with disorders such as emphysema may be helped by supplemental oxygen at high altitudes.

A wheelchair restraint system is a useful device for accommodating wheelchair users on trains. The restraint system retains the wheelchair by mechanisms which hook over the wheel tires and pull the wheelchair backward and downward against the floor. The system can accommodate wheelchair widths between 450 and 750 mm and wheel diameters between 500 and 600 mm. An upholstered headrest provides a rear cushion if the occupant's head moves back. A snack tray can attach to the wheelchair armrests. A wheelchair restraint system such as this one is invaluable for allowing disabled persons to travel on trains safely.

Among disabled train users, the main problems are platform access (steps and stairs) and carriage access (step height, lack of handholds, and door widths). Specially designed facilities are needed in train stations and railway cars to accommodate disabled passengers. Examples are automatic doors and specially trained attendants. Modification to station access such as automatic doors, accessible washrooms, rest areas, handrails, standardized step heights, curb cuts, elimination of grade changes, and elimination of hazards to the sight impaired are also important to increasing the mobility and travel safety of disabled and elderly rail passengers, and everybody else too.

Wheelchairs are 106.7 cm long x 63.5 cm wide x 91.4 cm high, and 27.9 cm wide when folded up. The measurements indicated however vary with model and manufacturer and each chair should be measured individually. The length of the chair is particularly important since it determines turning radius. The average turning space is 160 cm. These measurements are important in calculating wheelchairs clearance in aisles, washrooms, etc.

2.4.10. SLEEPING

To minimize noise for sleeping passengers, roomettes and sleeping compartments should be sound insulated. Insulated doors are especially important to minimize noises from the corridor. Ideally, the passengers should be able to prepare their own bed for sleeping. This allows passengers to go to bed whenever they wish and saves staff.

2.4.11. INTIMATE SOCIAL BEHAVIOURS (BOTH POSITIVE AND NEGATIVE)

Arguments, fights, care and affection, and sexual activities may occur on trains without regard for the sensibility of other passengers. Design of passenger accommodation should take these annoying or potentially unpleasant social situations into account. For example, it would not be a good idea to make a passenger coach too quiet because then all social noises (eg. whining child) would become too evident. Background noises provide privacy. Also, sound insulation between bedrooms and in the sleeping corridors should be good enough to provide a quiet night and keep the sounds of snores and copulation from disturbing those in the next roomette.

To facilitate privacy regulation, face-to-face seating arrangements should be optional. This way passengers who do not want to interact with others do not feel obliged to and those who do want to interact will be able to do so easily.

2.4.12. SMOKING

Non-smokers are often bothered by the cigarette smoke of smokers sitting nearby and have a right to be protected from this annoyance. For this reason, a certain number of isolated seats should be allocated for smokers. Ashtrays should be installed on these designated seats to minimize butts on the floor.

2.5. TRANSITIONS BETWEEN ACCOMMODATION SPACE AND PUBLIC SPACE

It might be helpful to provide some signal to passengers when the train is going to start, stop, or change speeds, since unexpected accelerations are more likely to cause a loss of stability in a passenger who is getting up or standing.

Research demonstrates the need for handholds when changing levels. Also the use of moulded plastic housings for rail passenger seats permits simple handholds to be incorporated without creating protrusions. However, toxic smoke production in a fire is a possible problem with moulded plastic fittings.

Automatic sliding doors with sufficient width are helpful for people carrying things and for disabled persons who are not strong or fast enough to open an ordinary door. Non-automatic or self-closing sliding doors might be advantageous for entrances to washrooms and roomettes.

In view of the frequent movements of passengers, the minimum gangway width between seats should be 530 mm. Above the backs of the seats the handrails should be set to give a useful gangway width of 600 mm. Wheelchair access requires more room.

A standing space of 1.5 square meters per person should be considered minimum. A suggested minimum standing height (to allow for ventilation and air conditioning) is 2100 mm. Areas for standing passengers should not have any sloping sections. If they are unavoidable, they hould have no more than 6% slope.

2.6 ACTIVITIES IN COMMON OR PUBLIC SPACES

2.6.1. AISLES

When people pass through a queue they often came into bodily contact with those in the queue. This finding may be applied to queues on long-distance passenger trains. For example, a queue at a snack bar on a train will interfere with other passengers passing through the same aisle.

2.6.2. WASHROOMS, TOILETS

The height of a toilet seat found to be comfortable is from .3 m to .5 m. The range of angles found to be comfortable is between -6 degrees and +6 degrees relative to the horizontal. The seat angle does not have any effect on preferred seat height. The height of the front edge of the seat is an important cue for subjects when assessing seat height.

The lower figure (.3 cm) is best for children, and the higher (.5 cm) for elderly persons who have difficulty sitting and standing. For most passengers .4 cm is a good height. Appropriate hand rails, and perhaps a small step for children, would make the .4cm height acceptable for most passengers.

A comfortable height for a lavatory is 90 cm. The lavatory should be 69-74 cm wide to accommodate a circulation zone and activity zone around the sink.

The sink should have a curved overhang. When lateral accelerations move the water, these inward curved edges will direct the water towards the centre instead of over the edge.

In first class sleeping accommodation, a shower should be provided. An economical design combines a toilet and shower in the same compartment with a drain in the floor covered by a wooden or plastic grid.

2.6.3. LOUNGES, SNACK BARS, AND RESTAURANTS

Distance to be travelled often determines the type of food service required. Snack bar facilities with beverages and packaged food are suited to small, less patronized trains. A fast-food service with seating is best for medium volume patronage. For long distance travel, when patronage and timing permit, traditional dining car service should be offered.

Clearances for a typical food counter are 90 cm for workspace behind the counter, 61 cm for the countertop and 168 cm between the front face of the counter and the nearest obstruction. Most counters are about 110 cm in height. A sitting zone per person of 61 cm wide is needed.

Two counters arranged parallel to each other require an overall clearance measure from the front edge of one counter to the other of 150 - 190 cm. A public circulation zone between stools of 92 cm is needed. The clearance between tables in a low volume operation dining space should be 214 cm. The service aisle between chairs should be 92 cm.

Meals should be provided on trips that are longer than 2 1/2 hours. For the mid-distance traveller - 4 to 12 hours - the preference is for fast food service. At the 12 hour end of the continuum, good-class food service and a diner where full meal service is provided at the proper times is essential.

The primary features in passenger requirements for food service are:

- reliability in the provision of facilities advertised
- good food and service
- an efficient, cheerful staff
- variety of good choice
- value for money.

2.7 GENERAL PSYCHOLOGICAL CONSIDERATIONS

2.7.1. REGULATION OF HUMAN CONTACT

Each train passenger requires a certain amount of personal space to feel comfortable. Since many passengers may not want to interact with his/her fellow passengers, some seats should be placed side-by-side, not facing one another. This prevents eye contact when it is not wanted.

At some time during a long journey, most passengers will want privacy for intimate conversations or just to be alone. There should be places conducive to being along, such a small jump seats in the vestibules.

2.7.2. RELATION BETWEEN PERCEIVED COST OF FURNISHINGS AND COMFORT

Bed sheets should be made from polyester and cotton for optimum comfort and to minimize the cost of ironing. Curtains should be made of flame-resistant polyester. Seat covers should be a woven nylon, wool or polyester blend for optimum comfort and durability. The main requirement is for furnishings that remain attractive after years of use and maintenance.

2.7.3. RELATION BETWEEN PERCEIVED CLEANLINESS AND COMFORT

For cleanliness and absence of smell, all materials in the interior of the vehicle must be dirt-repellent (anti-static) and not liable to damage from sharp objects. Well chosen decor can help to combat liability to soiling and conspicuousness of soiling. All interior walls and floors should have continuous surfaces having no sharp mouldings with dirt grooves, corners or recesses. Unavoidable recesses should be large enough to be cleaned with a broom.

Perceived cleanliness in toilets requires frequent inspection of facilities, cleaning when needed, and provision of sufficient soap, hot water, paper towels, paper toilet seats covers, and special waste containers for articles such as soiled disposable diapers. Good ventilation is essential in washrooms.

2.7.4. PERCEIVED AND ACTUAL SAFETY

To reduce the danger to standing or walking passengers due to sudden stopping or acceleration of the train, announcements to that effect should be made on a public address system to warn passengers. Handholds should be provided on top of the seats and in the toilets.

2.7.5. PHOBIAS, FEARS

A few years ago, Behavioural Team studied acrophobia as it related to elevated section rail travel. It was concluded that higher window sills would reduce fears. For those experiencing claustrophobia, it was felt that the design of emergency notices needed special care. In particular "screaming" reds should be avoided.

2.7.6. STRESS REDUCTION

Passenger stress can be reduced by providing for a variety of potential spaces and behaviours. Passenger control over their own environment through such features as air vents and reading lights also reduces stress.

2.7.7. ENTERTAINMENT, FESTIVITIES

It has been found that games are not highly valued by most train passengers. However, this may be because games are not usually available. This suggests that computer games and interactive computer systems might be an added bonus for long distance train passengers who are often bored. Also, weak radios in the roomettes would probably be well received.

2.7.8. SPECIAL TRAVEL GROUPS

Piaget's studies of cognitive development suggest that children between the ages of two and seven cannot understand the points of view of others. They focus primarily on one feature of a situation. These characteristics indicate that children between ages two and seven are too young to travel alone and require considerable supervision from an attendant.

Between the ages of seven and eleven children are capable of focusing attention on more than one aspect of a situation. These children would need only a moderate degree of assistance for unaccompanied travel.

Between ages eleven and fifteen, children are able to derive a number of solutions to any given problem and therefore should be able to travel unaccompanied.

The rail industry should develop travel policies to insure that unaccompanied children are adequately protected and supervised.

Some special travel groups, such as sports fans, may require additional precautions, Plain clothes security personnel should be utilized in any rowdiness is anticipated.

3. INTERACTIONS WITH RAIL PERSONNEL

3.1. IDENTIFYING HELP, INFORMATION, OR AUTHORITY FIGURES

Staff uniforms must be stylish but also live up to performance standards, i.e., be practical, comfortable, well-designed, long-wearing, and competitively priced. It is best to stick to one colour for uniforms to avoid laundering problems. The most popular fabric is a blend of 80% polyester, 20% cotton. Uniforms should be washable since they need to stand up to frequent laundering. A good uniform will last 9 months to two years. Ample stretch room is needed under the arms, across the back and around the chest and wasit for employees who move around a lot, lift things, or stretch. Pockets are recommended for staff who must carry a notebook and pen.

Passengers should receive some information on how to identify train staff, and the expected duties of the different staff members.

3.2. TRAINING AND DEMEANOR OF STAFF

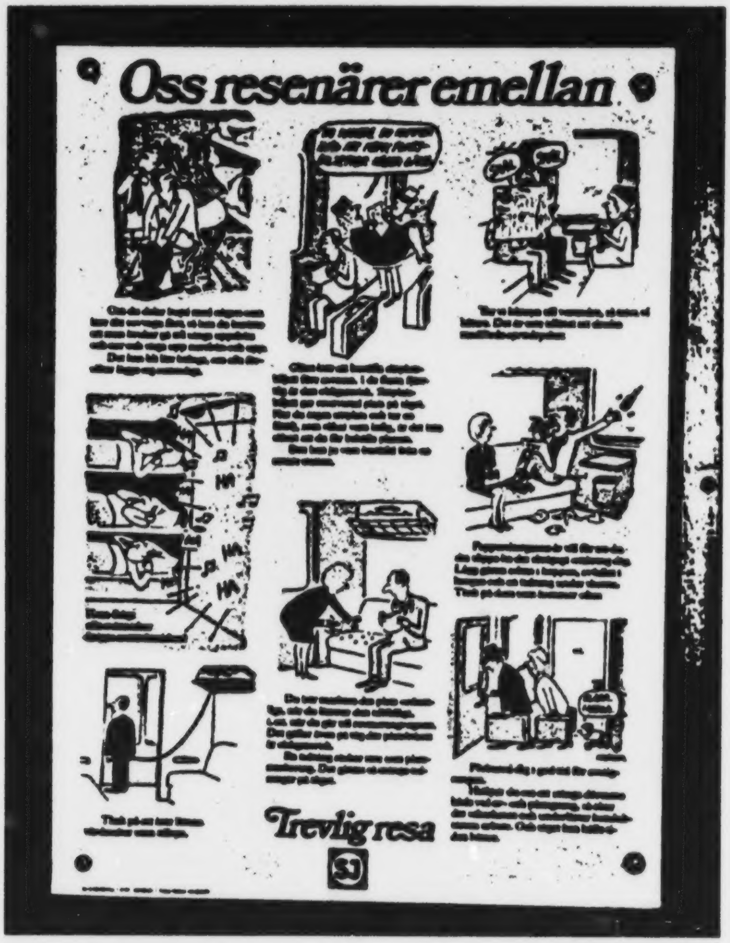
Staff require ongoing training and feeback concerning their interactions with the public. Staff should wear some identification (name or number badge) so that complaints or compliments about specific staff can be made. Any complaints should be dealt with in a constructive non-punitive manner.

3.3. EMERGENCY MANAGEMENT

Gravina smoke detectors are helpful in detecting fire. They should be located in every part of the car, linked to an electronic control unit that gives different levels of warning according to the condition detected.

Other emergency equipment includes a small hammer for exiting through a window, fire extinguishers in an obvious location in each car, and emergency medical equipment. Staff should receive some training in handling common emergencies.

Behavioural Team


Oss resenärer emellan
HA
HA
HA
Trevlig resa
SJ

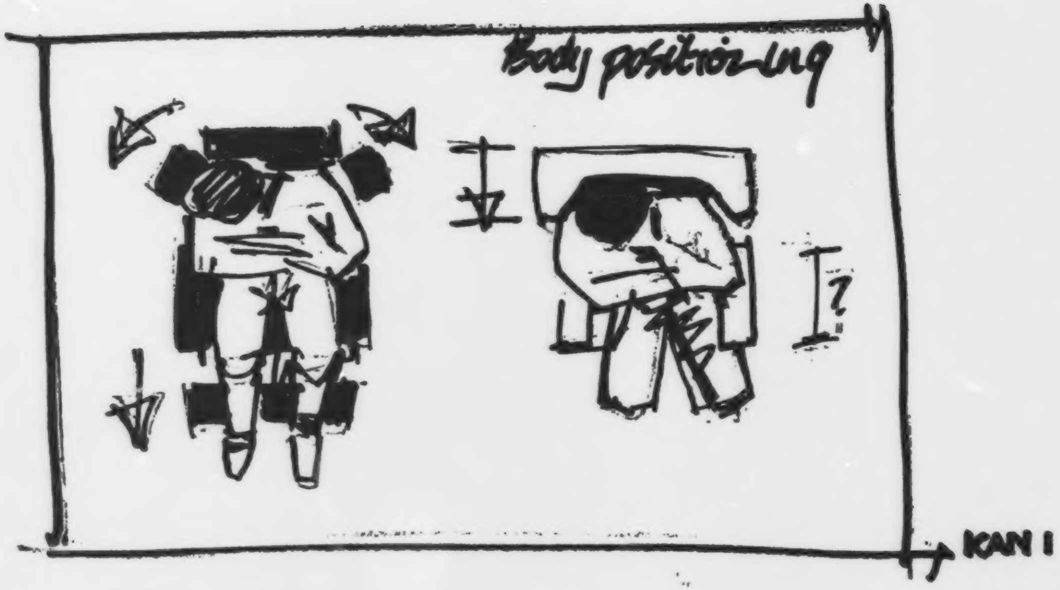
Kuypers Adamson Norton Ltd
Industrial Designers
Toronto·Vancouver

76 Richmond Street East
Toronto, Ontario, Canada
M5C 1P1
Telephone (416) 362 7737

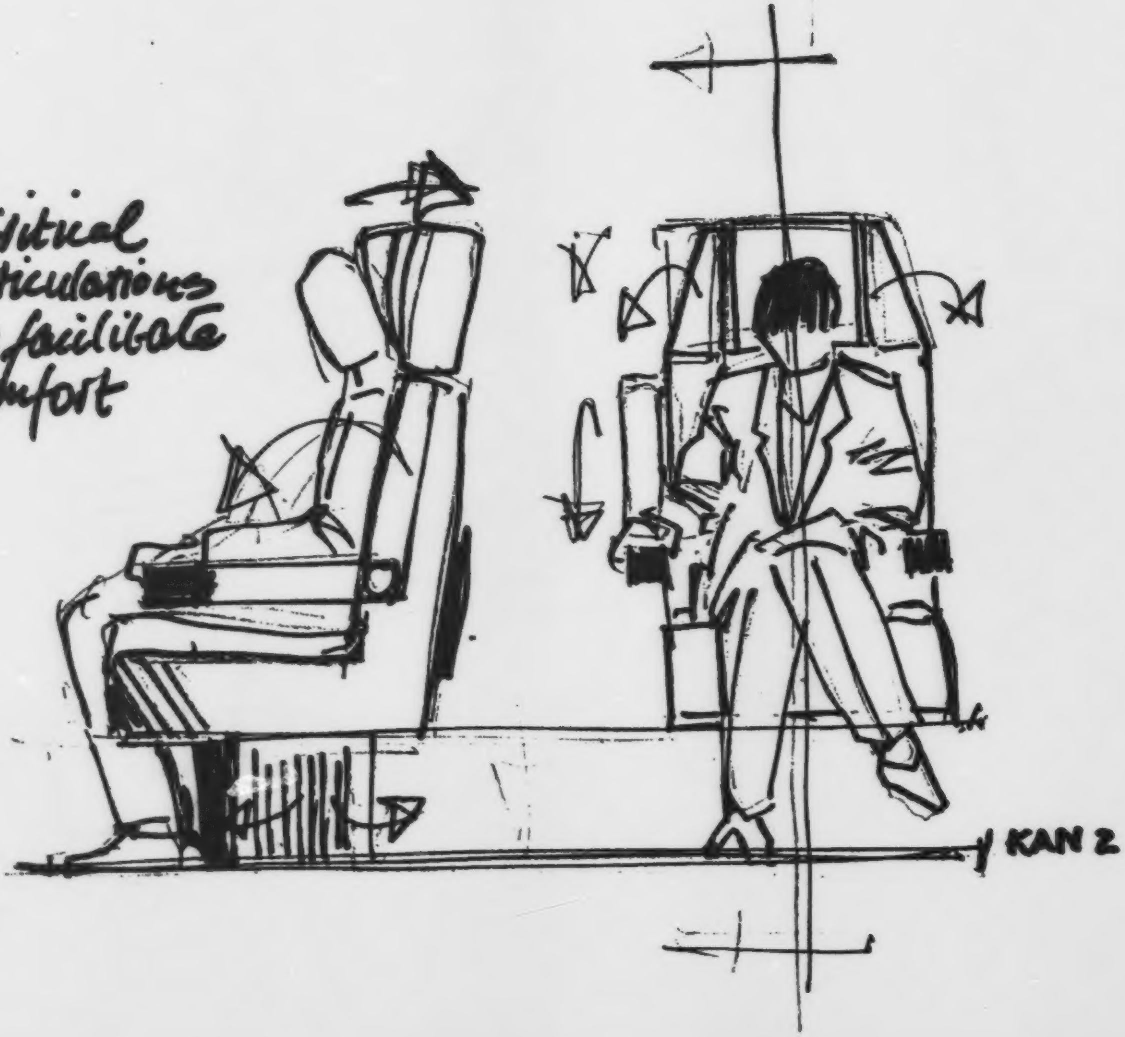
KAN

TRANSPORTATION STUDY

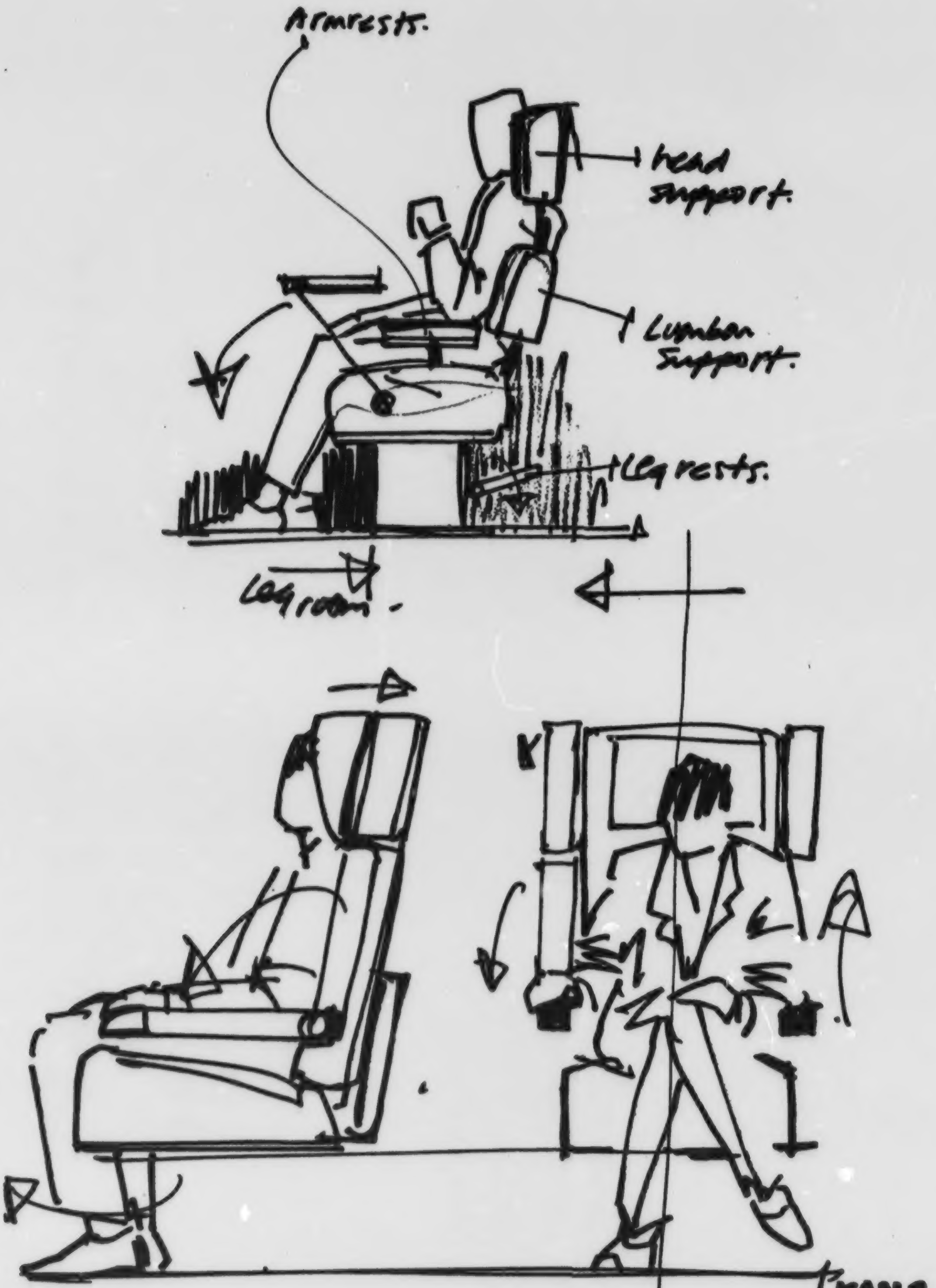
DESIGN SKETCHES 1 - 19

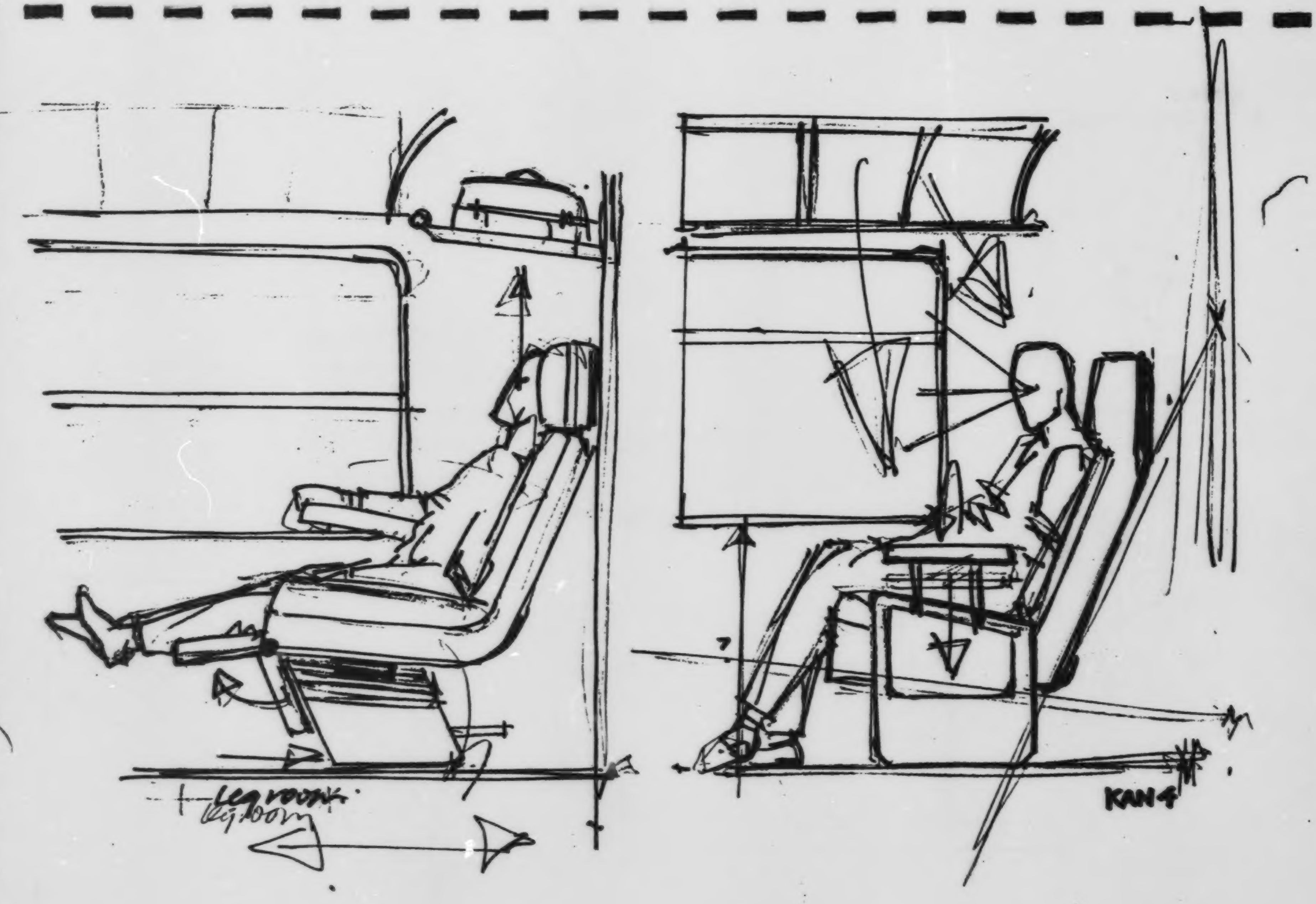

Body positioning
?
KAN I

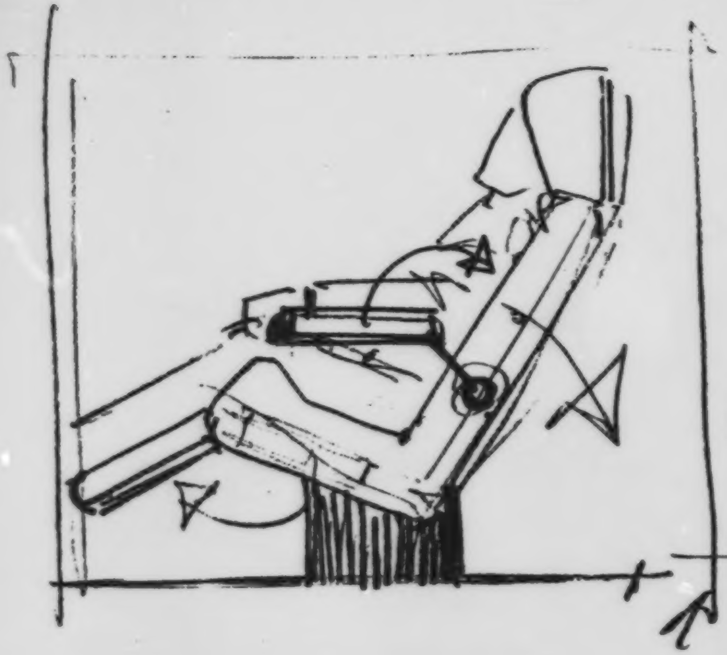
Critical articulations to facilitate comfort

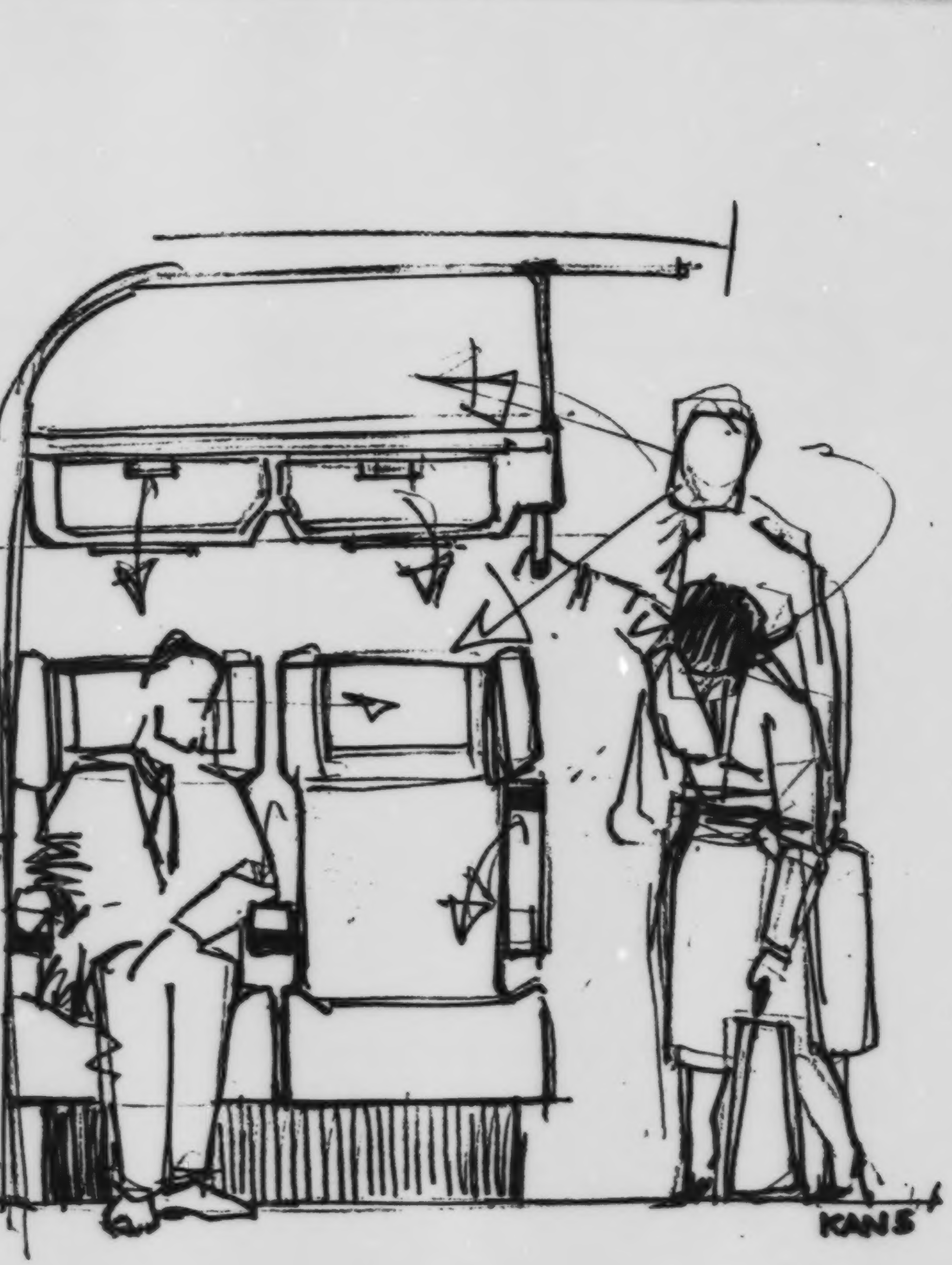


V

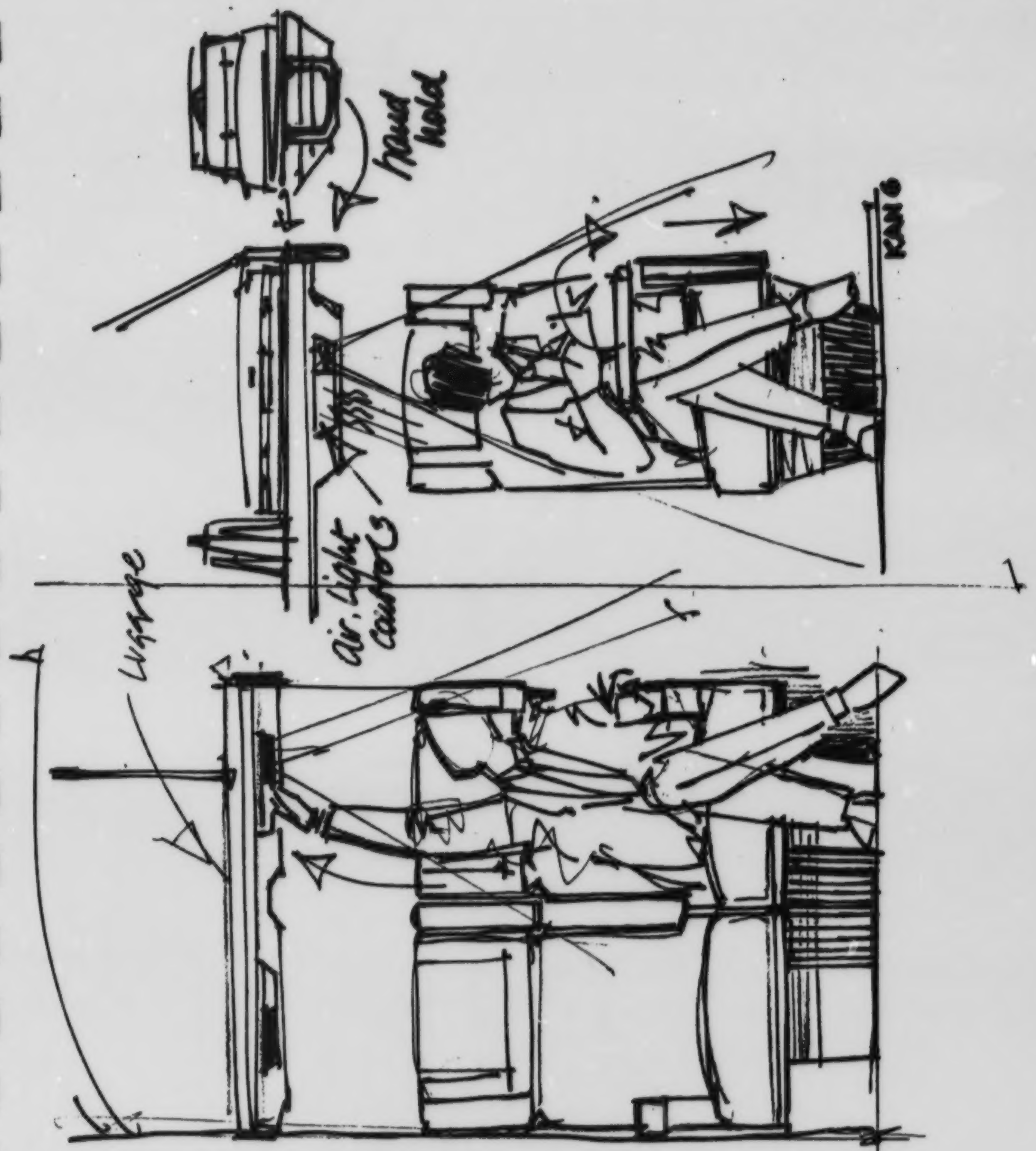

Armrests.
head support.
Lumbar support.
leg rests.
Leg room -
KAN3


legroom
legroom
KAN4





Individual
Storage
modules
One per seat
overhead.


hand hold
air, light controls
Luggage
KAN 6

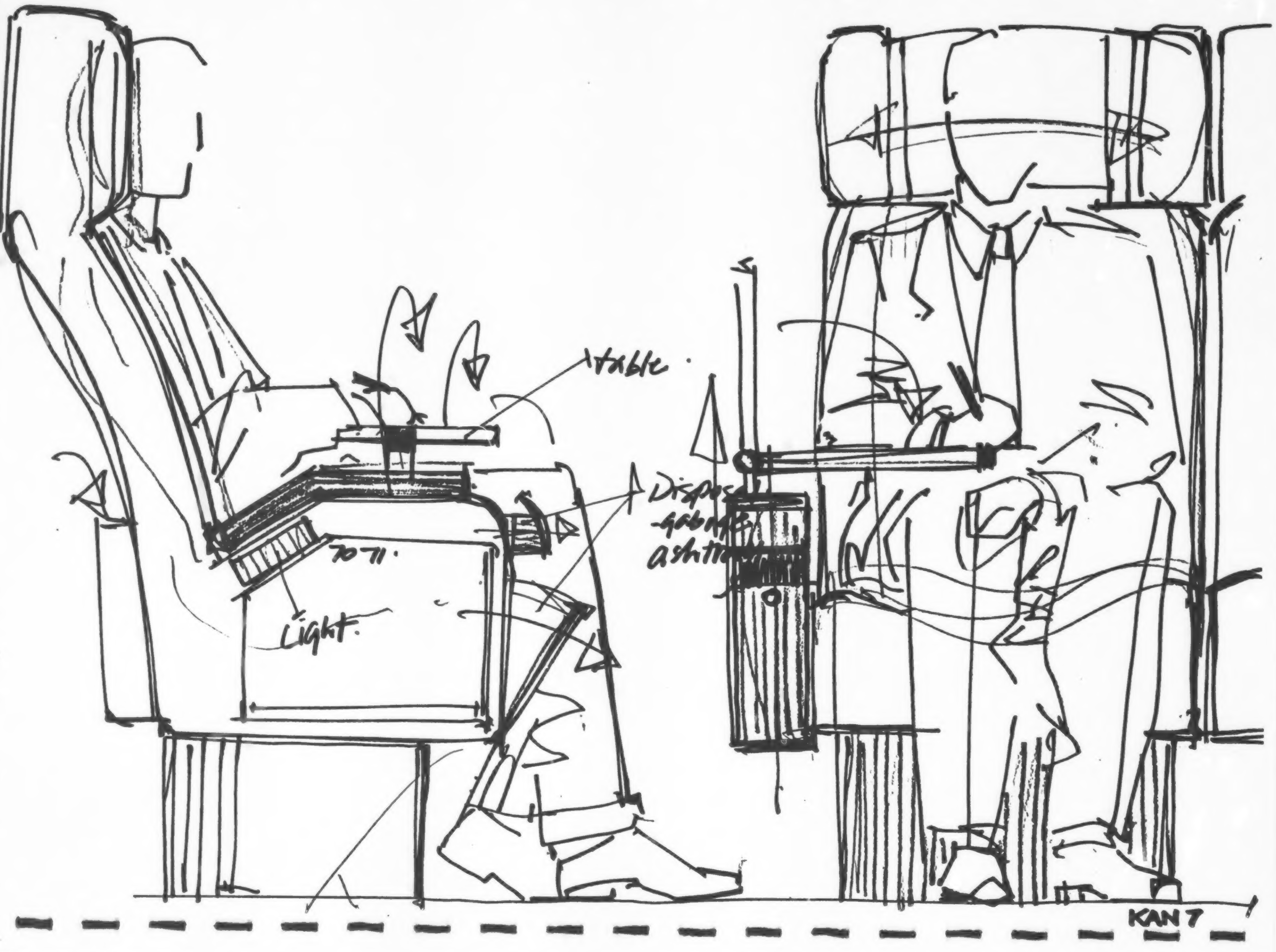
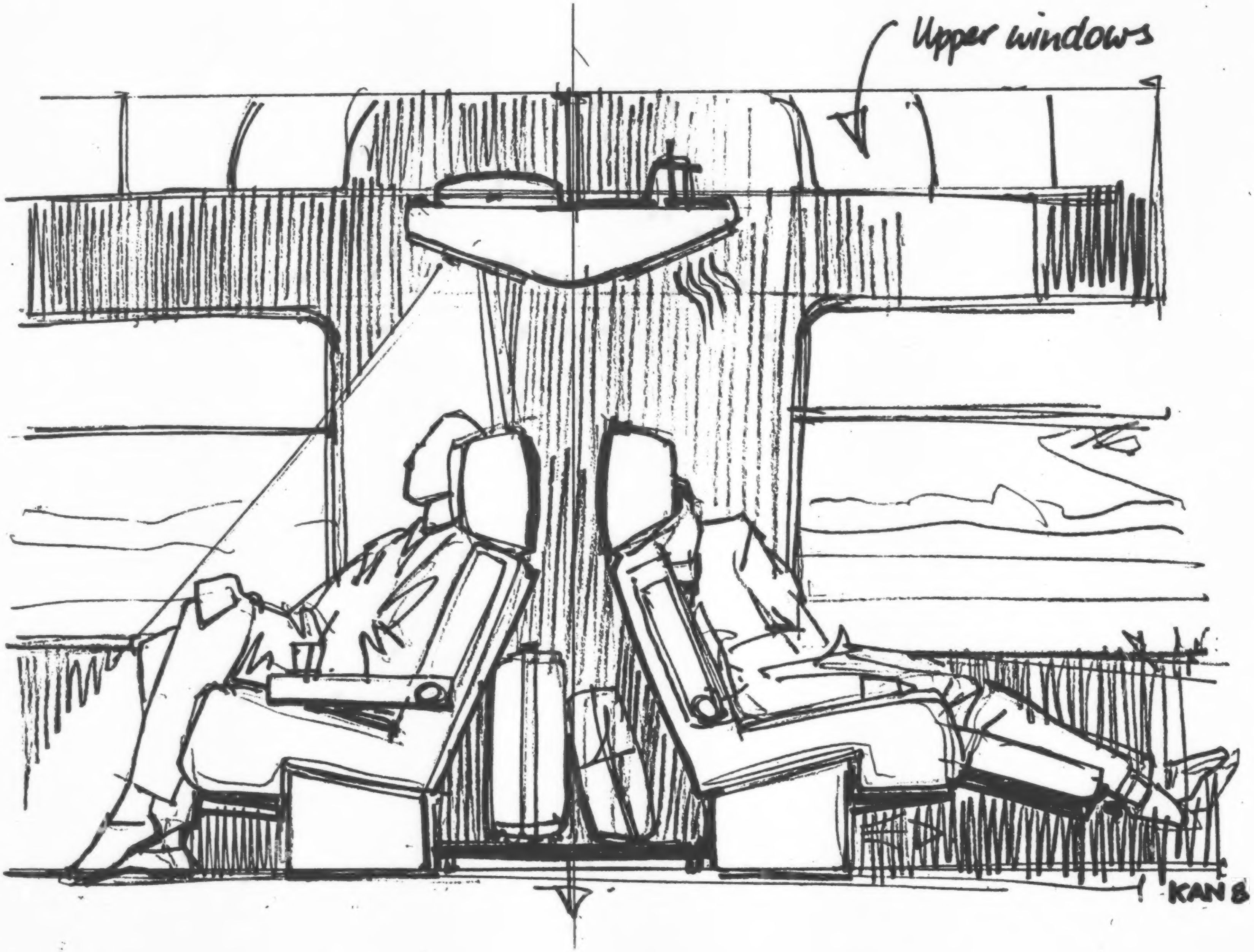
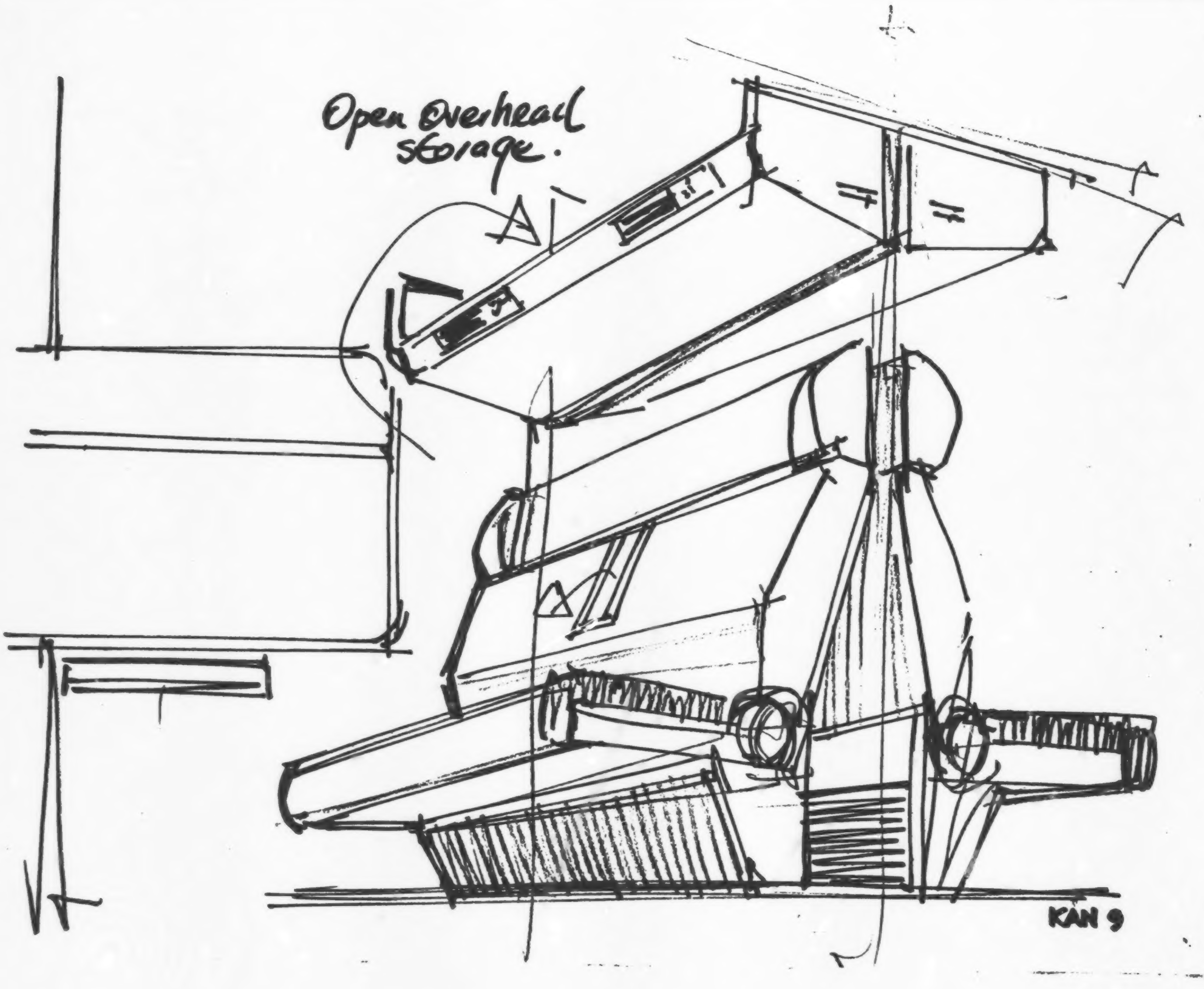
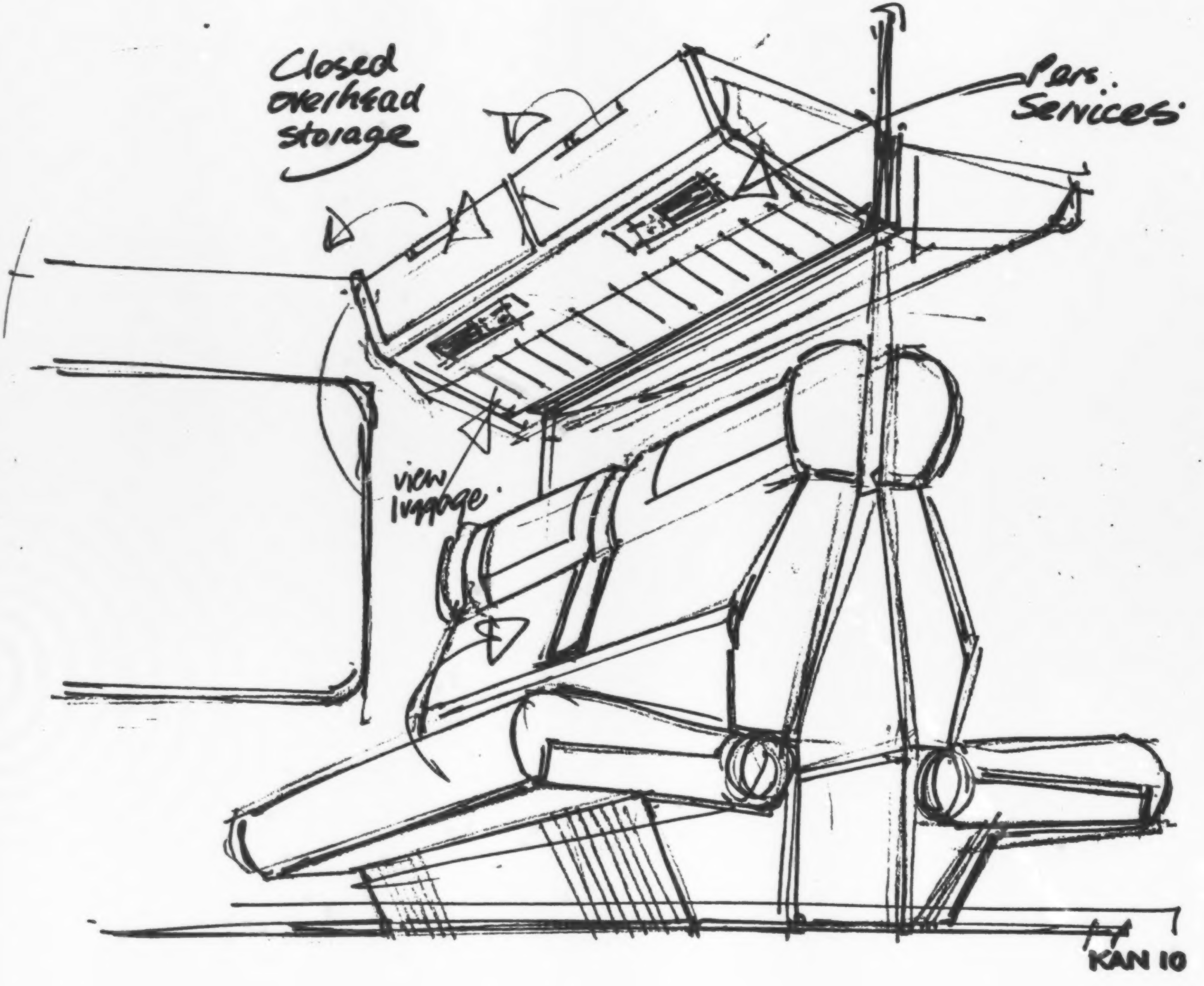
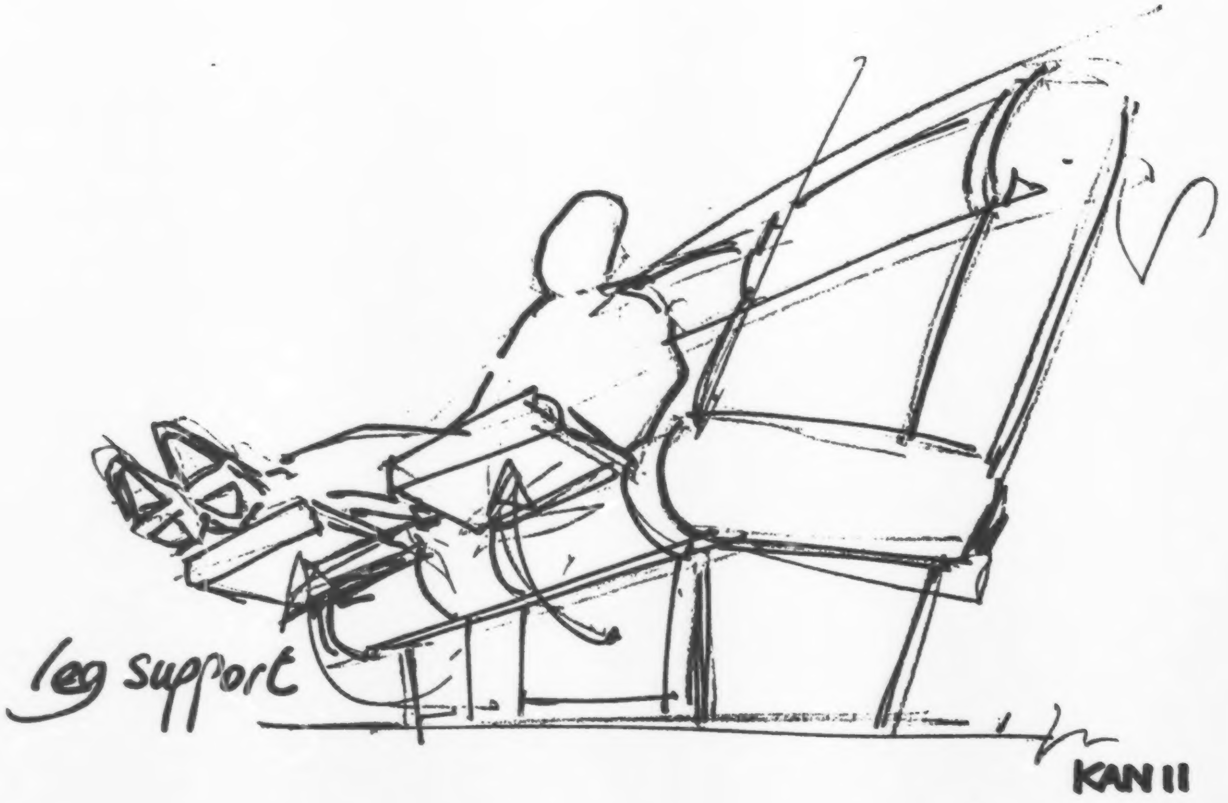


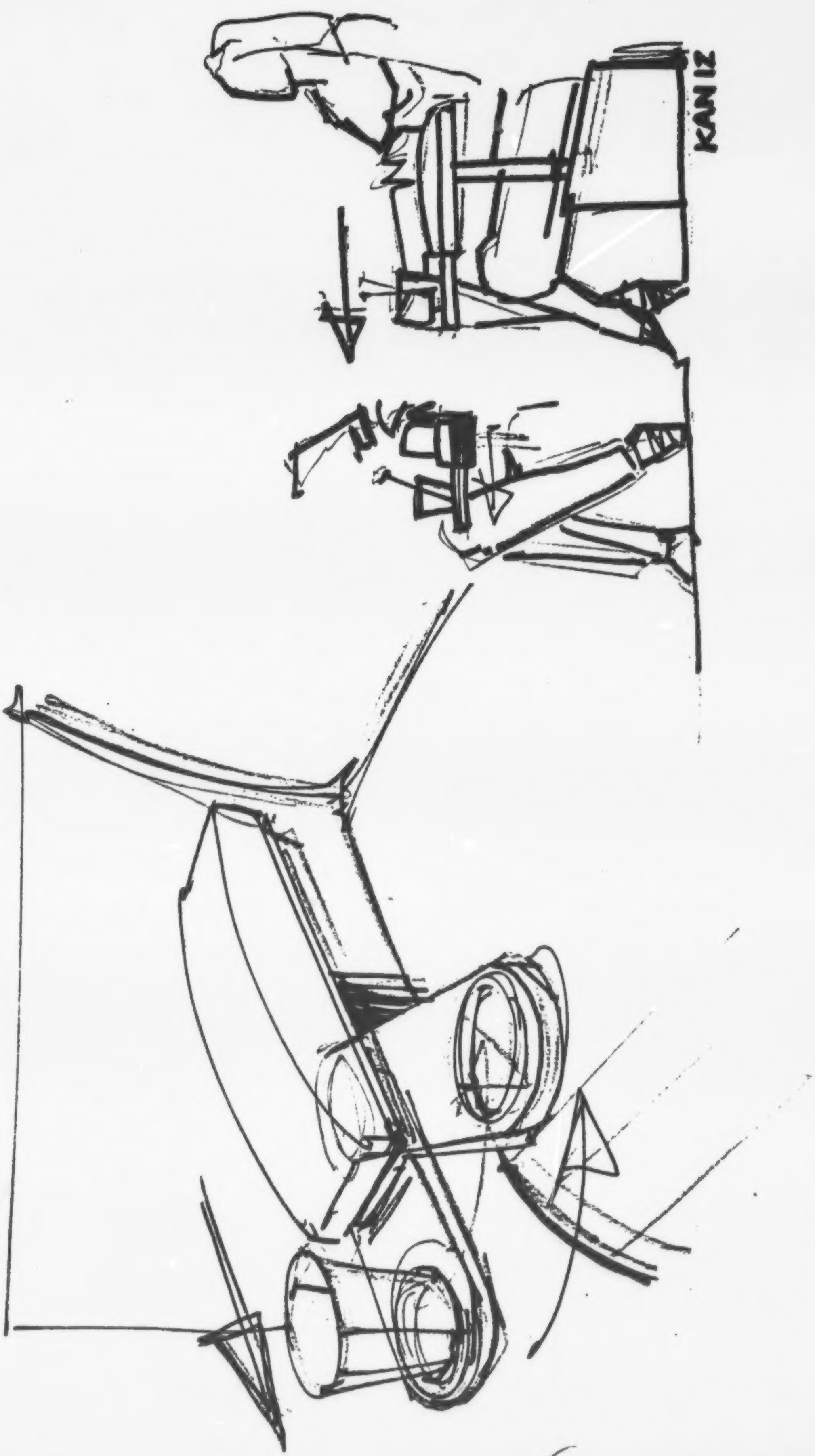
table.
Dispos-
-garbage
ashtray
70 71.
Light.
KAN 7

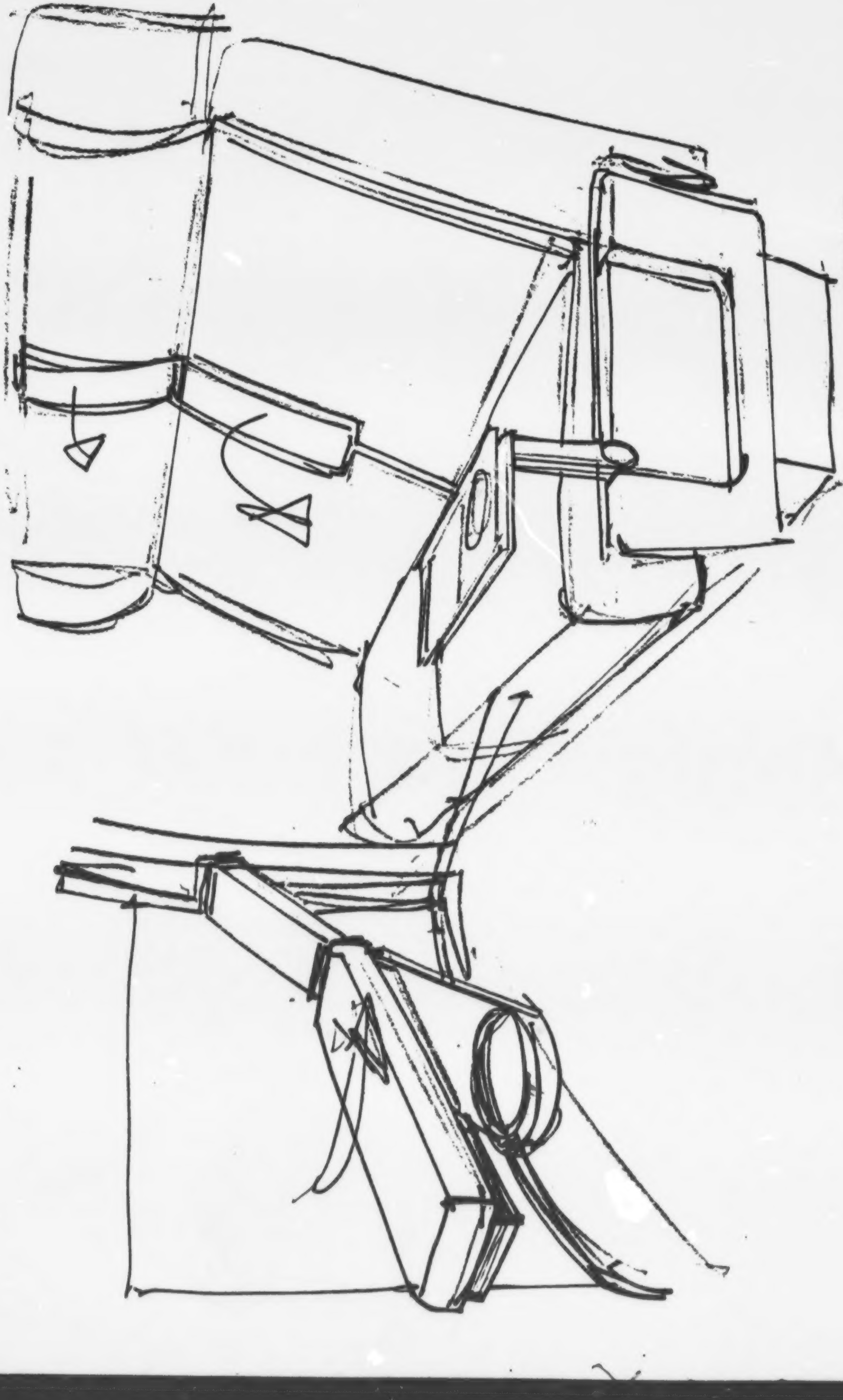

Upper windows
KAN 8


Open Overhead storage.
KAN 9

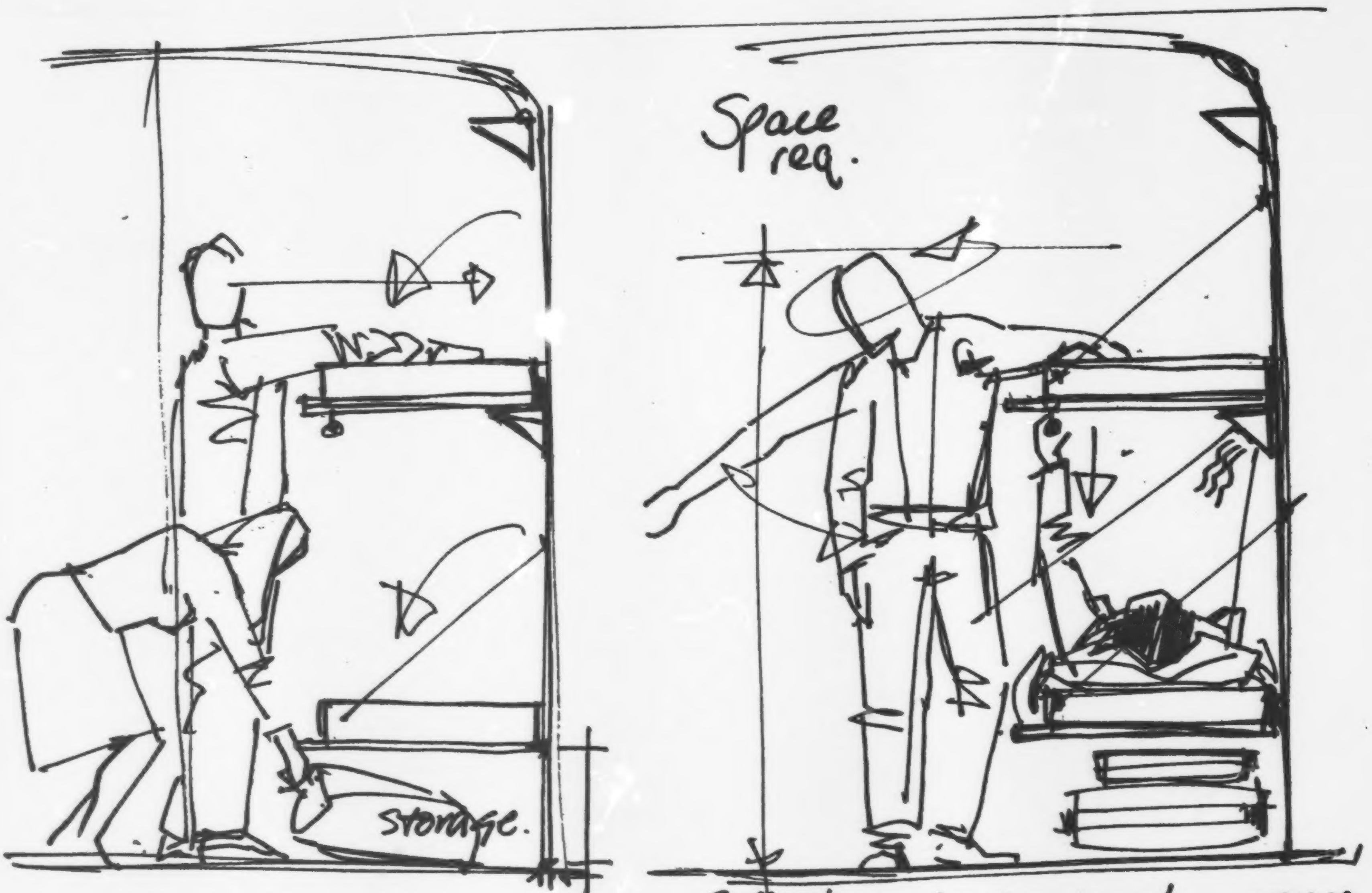

Closed overhead storage
Pers. Services
view luggage
KAN 10


leg support
KAN 11


KANIZ

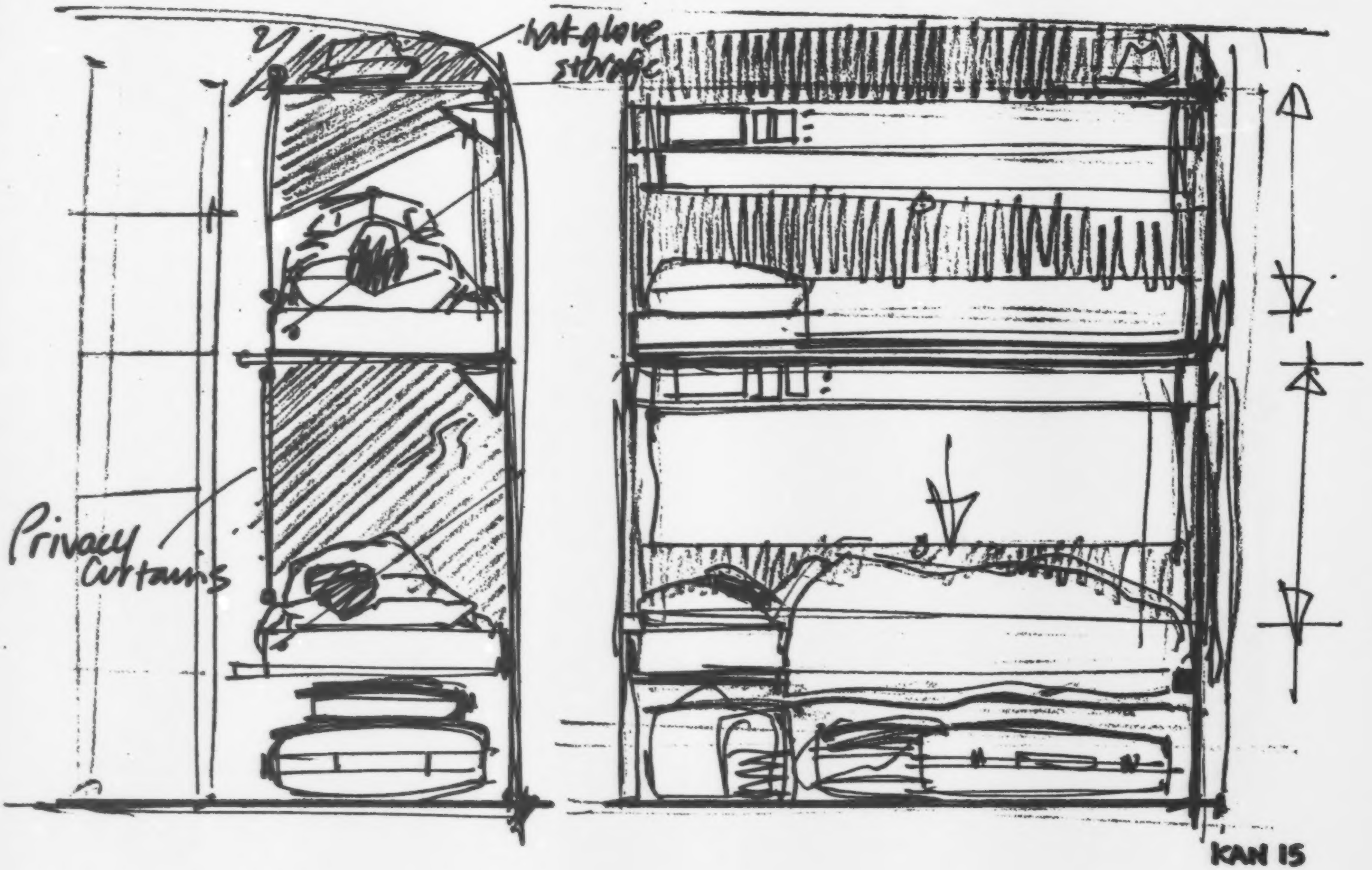


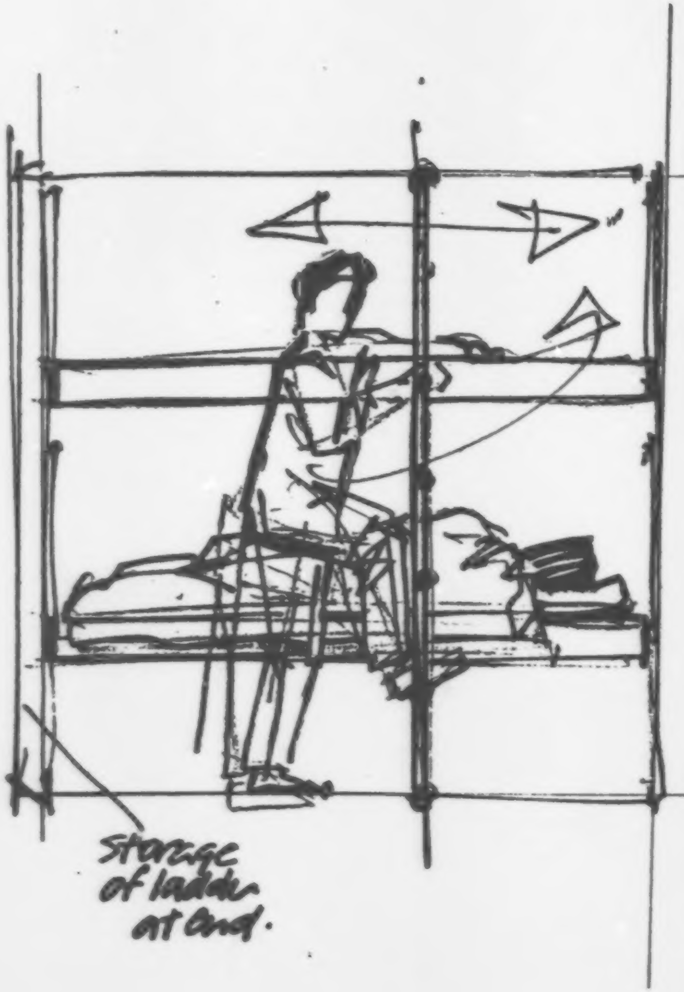
KAN 13

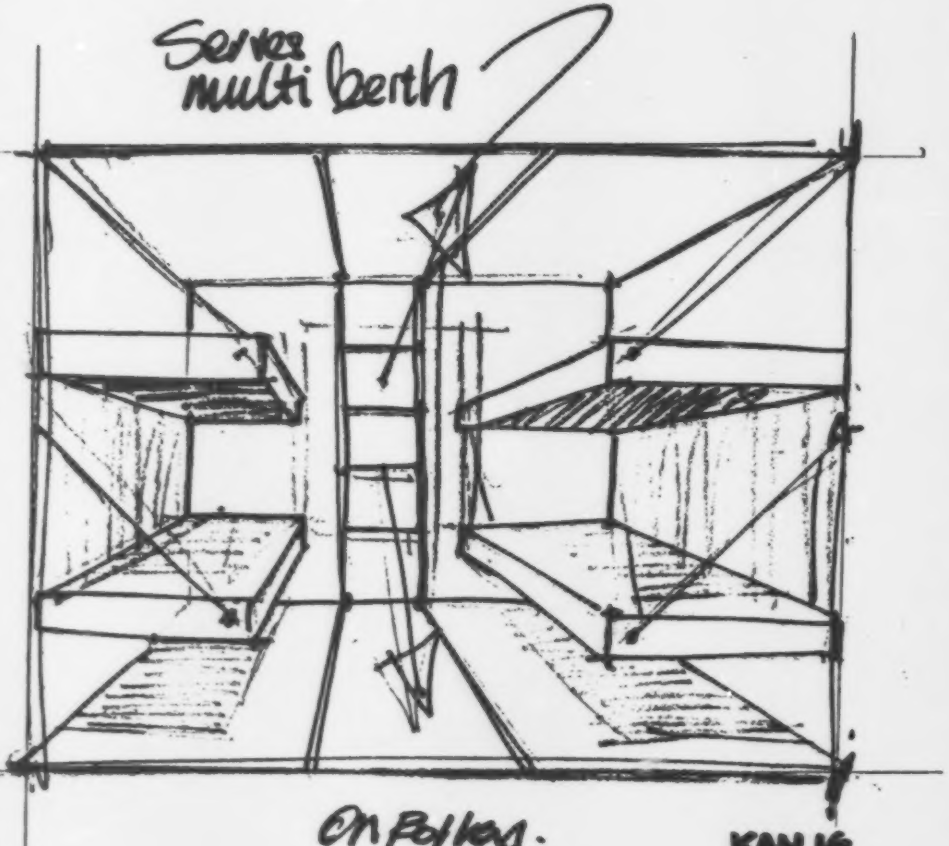

Space req.
storage.

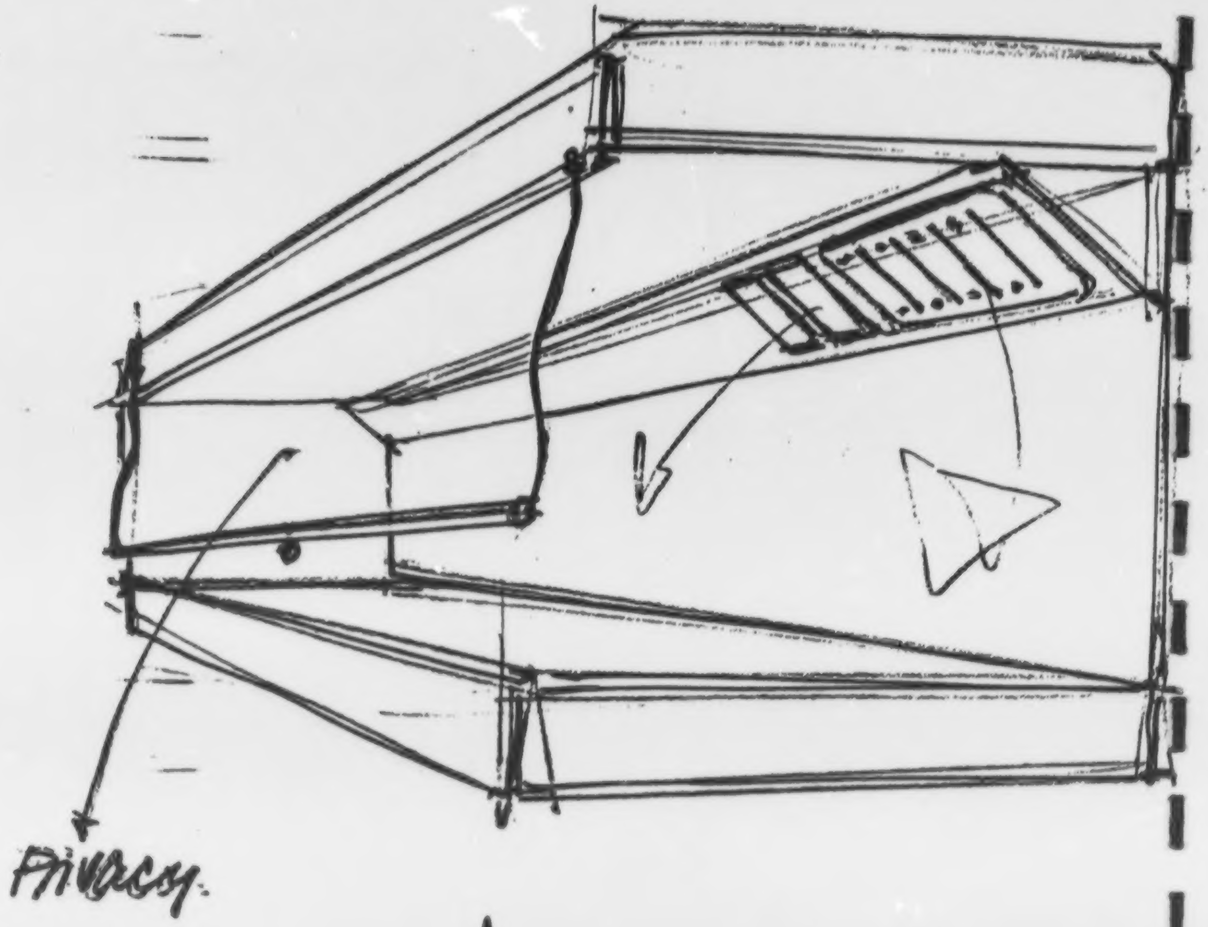
Sufficient space for changing, etc.

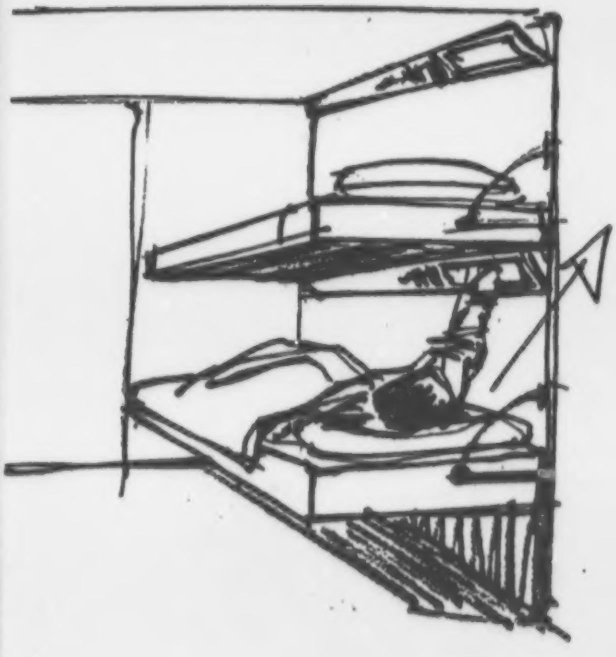
KAN 14


hat-glove storage
Privacy Curtains
KAN 15


Storage
of ladder
at end.


Serves
multi berth
On Rollers.
KAN 16


Privacy.



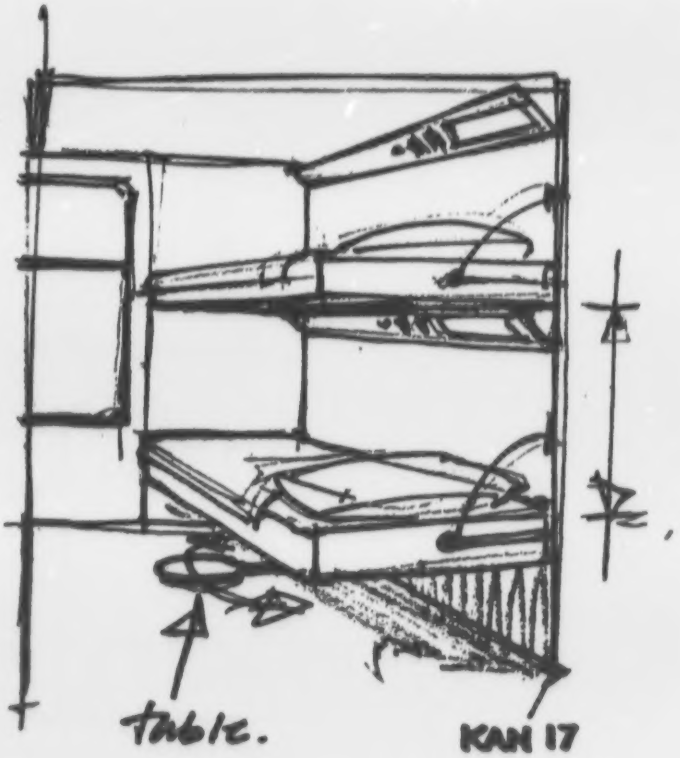
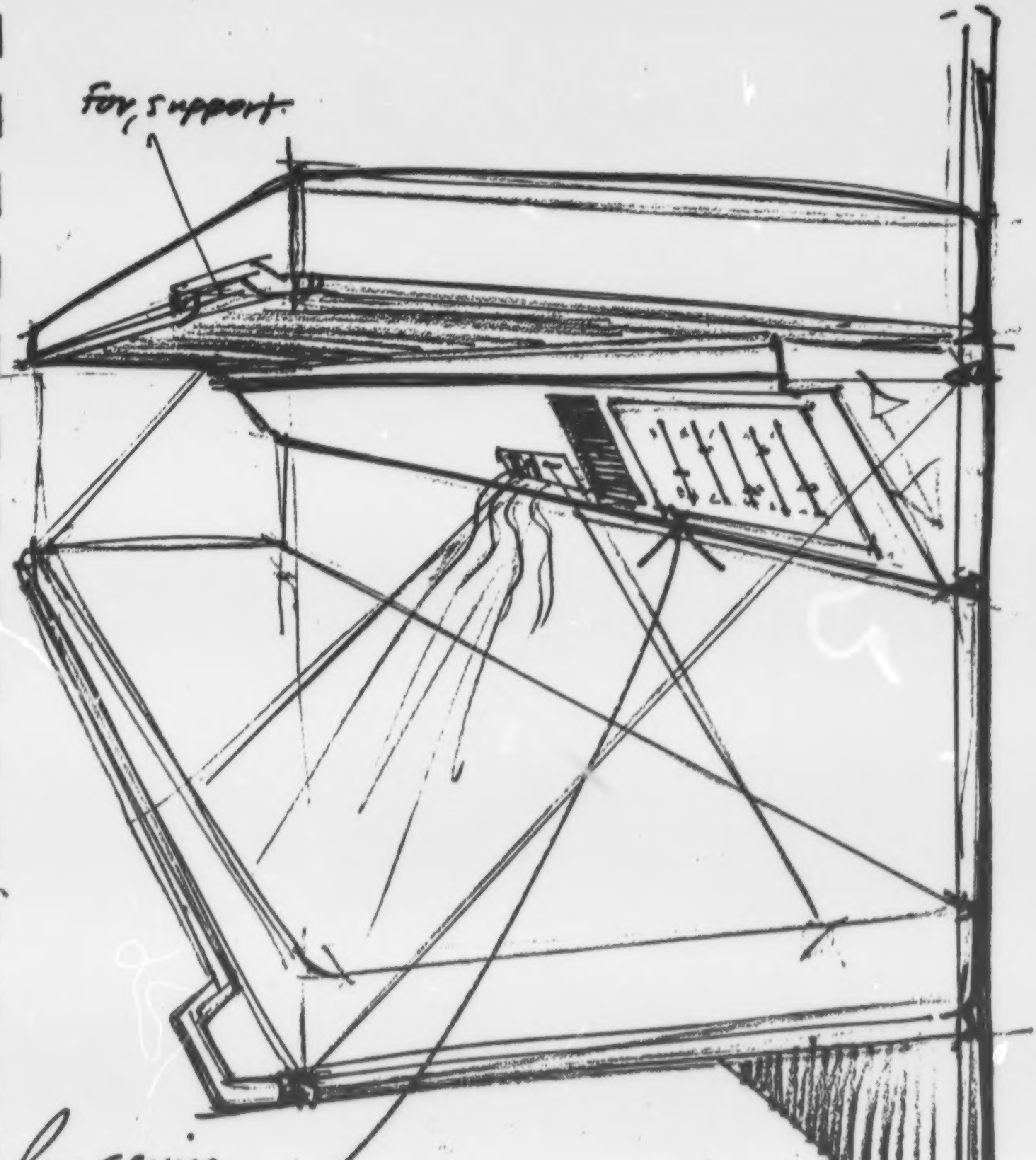
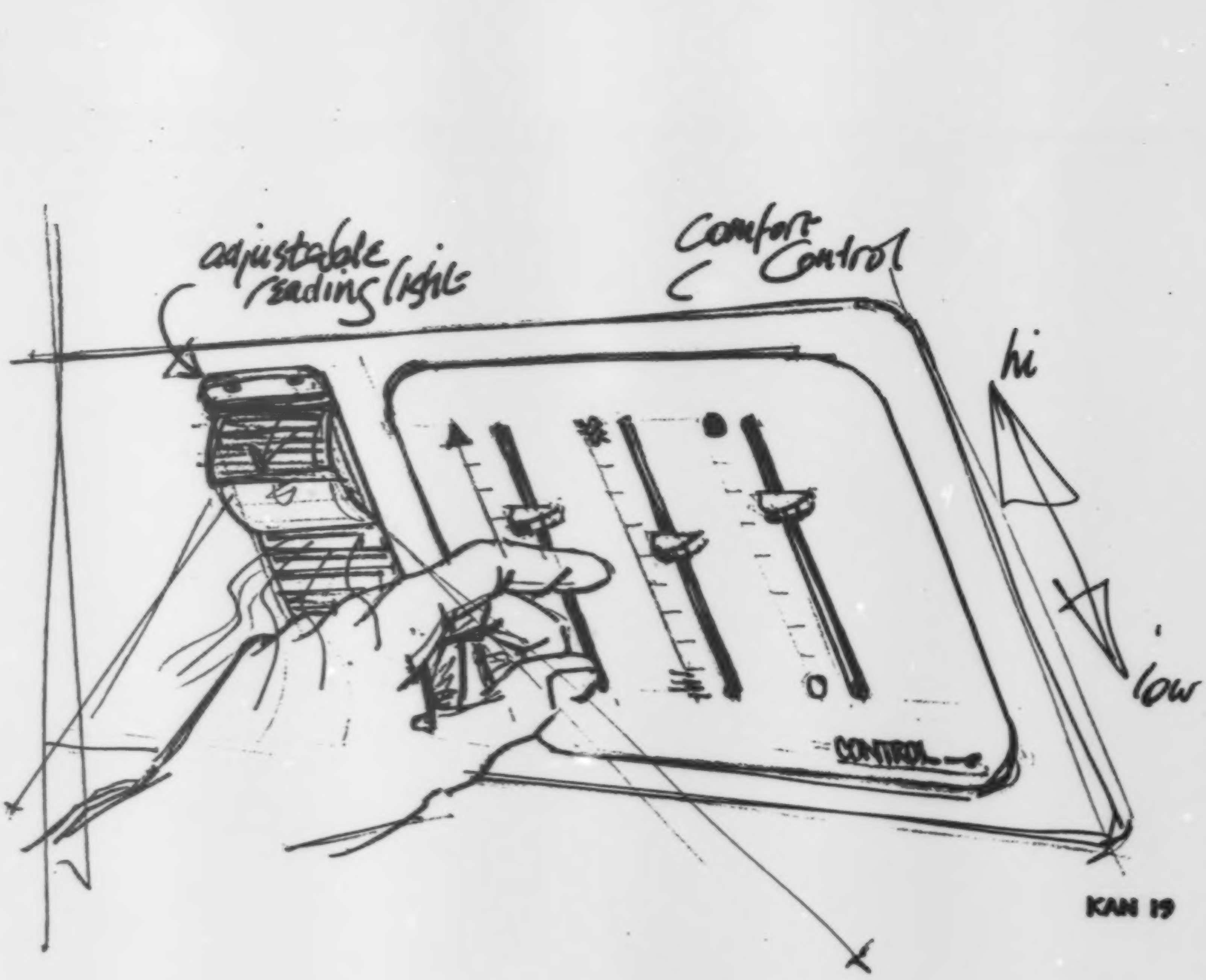


table.
KAN 17


for, support
Pers. service panel

KAN 15


adjustable reading light
Comfort Control
hi
low
CONTROL

KAN 19

Aspects of Long-Distance Passenger Train Design Requiring Further Research

TABLE OF CONTENTS

Introduction..2

A. Suggested Research..3

1. Analysis of Presently Available Data....................3
2. On-Board Studies of VIA Rail's Present Passengers.......4
3. Studies of Potential Passengers..........................6
4. Studies of Passengers with Special Needs................6
5. Studies Using Stationary Mock-ups and Operating Prototypes................................7
6. Fine-tuning Studies with New Operating Equipment........8

B. Gaps in Human Factors Information.......................9

1. Environmental Variables................................9
2. Behavioural Variables..................................15
3. Interactions with Rail Personnel.......................25

Introduction

Previous reports for this project have concentrated on defining and summarizing the present state of knowledge concerning human factors for long-distance passenger trains. These have included a review of the literature (task 4.2), an analysis of human factors in enclosed accommodation in current Canadian practice (task 4.3) and current international practice (task 4.4), a comparison of Canadian and international rail practice (task 4.5), and human factors design guidelines for new Canadian long-distance trains (task 4.6.)

Our reports cited above - and others we have prepared over the years - are filled with practical information. However, there is still much that we do not know concerning Canadian passengers and their perceptions, preferences, and problems on long train trips. In particular, more needs to be known before designers can confidently apply their creative imaginations to our human factors functional specifications.

The present report deals with these gaps in the knowledge base. The format will therefore be somewhat different from that used in the previous reports. The questions have been organized according to the same human factors taxonomy used in the previous reports, and are found in the second section of this report. Under each section in the taxonomy, the most important unanswered questions are listed, with brief explanations where necessary.

In the first section, research strategies are described which can help answer these questions. The basic research methodologies which can unravel most of the important questions posed here are presented. Some appropriate research designs are outlined in the first section and the range of relevant questions are identified in the final section.

There are many small unanswered questions for each topic in the taxonomy. We have only listed those human factors questions which, in the perspective of this thorough multi-report activity, must be addressed before starting the design of new, Canadian, long-distance rail passenger cars.

We have not listed other questions that are prompted by models of traveler behaviour, competition between different modes, marketing strategies, or professional curiosity. Likewise, we have not listed the many questions concerning technical specifications of possible equipment. In essence, we have listed the major unanswered questions concerning the passengers.

A. Suggested Research

Several different programs of research are outlined below. Each approach can address a number of outstanding questions concerning human factors for long-distance trains. The different research programs are defined according to the population being studied, the primary methods of presenting questions or situations, and the means of gathering information.

In summary, these approaches are -

1. Professional development of methods to tap into available information reflecting passenger happiness and misery.
2. Close, professional attention to the behaviour and attitudes of people while they are riding VIA Rail trains.

3. "The ones who got away" or non-users.

4. Passengers with special needs.

5. The testing of realistic patrons on mock-ups and semi-functional prototypes which re-create the psychologically and behaviourally significant aspects of the final design.

6. Fine-tuning and "post-occupancy evaluation" of new rolling stock using samples of people and professional methods of data development.

1. ANALYSIS OF PRESENTLY AVAILABLE DATA

There is a large amount of potentially relevant data which has not received enough attention. This includes information on accidents and mishaps involving passengers, complaints from passengers, problems reported by crew and service managers, maintenance problems, and utilization of various accommodations, services, and facilities.

VIA Rail has begun to systematically record and tally complaints from passengers. However this has only involved situations when a passenger has written a letter to complain.

The procedures now instituted at VIA Rail are useful. But with all due respect, they are not prepared with the needed professional judgment and thus can not serve as well as they should to guide VIA Rail's management. For example, less formal complaints, such as phone complaints or comments to crew members should also be recorded. Some characteristics of the passenger making the complaint should be included to identify which segments of the passenger population are most likely to have a particular problem. Some passengers may have sensible suggestions for avoiding the problem, so such suggestions should also be noted.

The same type of analysis should be applied to data on accidents and mishaps. The ones leading to some claim for monetary compensation for losses, damages, or injuries are obviously the most important. But cases where minor mishaps occur should also be scrutinized for information on problem areas in the train and its operation.

A great deal of valuable data could also be generated by some structured feedback ("de-briefing") from VIA Rail personnel dealing with the passengers. This shouldn't take the form of tedious reports for each passenger complaint or problem. Well designed coding and rating procedures could make it easy to determine the importance of various human factors problems affecting the passengers. The human factors problems of the staff should also receive more attention. Interviews, Focus Groups, and observations conducted by behavioural design specialists outside of VIA Rail could provide objective insight into the human factors problems in the delivery of services to the passengers.

In all of these cases, analysis of the data requires:

a) developing coding systems that can easily classify the frequency and severity of problems and also retain specific information about perceived causes,

b) assessing the relative costs of problems in terms of claims, lost revenue, stress on staff, maintenance requirements, etc., and

c) evaluating suggestions from passengers, staff, and experts for solutions to the problems.

The other area of available data concerns patterns of use of different accommodations on long train trips, demographic characteristics of present travelers, size of travel groups, and other typical market research data. Although some of this data may be available now, more data specific to long-haul train travel will probably need to be collected, organized, and, most important of all, cannily interpreted. This traditional approach, and some better ways to get information concerning the human factors needs of present passengers, are outlined next.

2. ON-BOARD STUDIES OF VIA RAIL'S PRESENT PASSENGERS

On-board studies of long-distance train travelers should include observations and interviews as well as written questionnaires. In some cases the important questions can be easily presented on a questionnaire and the replies of passengers are likely to be valid. In other cases, either

a) the question requires further refinement through interview or observation, or

b) valid information can only come from observing actual behaviour or discussing issues in depth.

The observations and interviews/discussions should take place before any major on-board surveys or questionnaires are designed. This would assist in the design of a maximally informative set of survey questions and rating instruments. Observations can reveal human factors issues that the passengers may not even be aware of as problems. Discussions and interviews can elucidate passengers' feelings and perceptions, and can also serve as a pre-test of questions for a survey. This is essential to ensure that passengers understand the questions and the alternative answers in the same way as the researchers!

Observations should generally, but not always, be unobtrusive. By using unobtrusive observations, the behaviour of the passengers should not be affected by the observer. They shouldn't even know that they are being observed. This requires considerable behavioural expertise and well planned observation schedules and protocols. In other cases, however, it is better to simply ask the passenger to show you how they would typically behave.

It is possible during an interview with a passenger on-board to ask him/her to perform certain activities such as operating (or attempting to operate) the reclining mechanism or putting away the folding tray. Again, considerable practical experience in behavioural psychology is required to know which behaviours can be usefully demonstrated on request and which require unobtrusive observation to yield valid results.

Of course, some passenger behaviours would not be appropriate for either demonstrations or unobtrusive observations. Even interviews and discussions have to be handled with considerable delicacy to determine even the peripheral human factors problems with using the washroom, sharing a bed, changing clothes, and similar activities. However, these behaviours are obviously important for passenger comfort and satisfaction. Experience in dealing with peoples' problems in sensitive areas is required to do this sort of work. Registered applied Psychologists have an advantage in directing these observations and interviews on-board, since they can ensure confidentiality and historically and legally well-defined professional standards.

These kinds of on-board studies with present passengers and equipment can be informative about many outstanding human factors questions. However, it can be argued that other methods are required to study potential new passengers and proposed new equipment, as well as specific target populations. In our opinion, there are not such great differences between able-bodied users and non-users as to materially diminish the universality of on-board collected information.

3. STUDIES OF POTENTIAL PASSENGERS

VIA Rail is in a rather unusual marketing position with regard to attracting additional passengers for long-distance train trips. During "peak" times there are too many passengers for the present equipment to handle. There is a need, however, to attract more passengers for the "trough" periods - any time except summer and major holidays.

It would be necessary to -

a) identify the specific market segments which might somehow be influenced to take long train trips in the trough periods, and

b) study representatives of these groups to see what service and equipment features might influence them to use the train,

in order to identify specific human factors contributions to attracting these passengers.

Some of these people may have never ridden a train on a long trip.* Others may have tried the train and discontinued using it for various reasons. These groups should be the subject of separate Focus Group and interview studies. Modern research techniques permit accessing appropriate subjects quickly and synthesizing their perceptions and preferences into clear recommendations.

Some of these potential passengers and the passengers with special needs, described next, should be included in the mock-up, prototype, and fine-tuning stages described below.

4. STUDIES OF PASSENGERS WITH SPECIAL NEEDS

"Special needs" includes a great range of individuals with physical and mental impairments which can be temporary or long-term. The recent Minister's statement makes it clear that carriers are expected to achieve very high percentiles of accommodation.**

There is a particular lack of human factors knowledge concerning train passengers with special needs. Some of their problems would be identified in the studies of available data, present passengers, and potential passengers. But specific studies should be undertaken to expand our knowledge about the human factors problems involved in long-distance transportation for elderly and handicapped persons, children, and other special travel groups.

The study methods are similar to those used for other groups - interviews, discussions, and observations leading to well designed surveys for appropriate questions. However, contacting representative subjects from these groups and extracting the relevant information requires experience dealing with special populations.

---

*The national-sample Behavioural Team study for Amtrak discusses this.

**The dignified and satisfactory transport of retarded Canadians was addressed in a recent Behavioural Team report to TDC.

In addition, covering the entire field of human factors concerns for each different special need requires a well organized research plan. The first step should be to develop a matrix of possible special conditions, both chronic and acute, and their possible human factors problems. The judgment of several relevant experts, including members of the special groups, could then be applied to identify the actual human factors barriers and problems in transportation.

For most of these groups we do not have reliable information for even the most basic human factors questions such as vibration and acceleration limits. For other groups more specific questions arise. For example arthritis sufferers may have special problems with luggage, handles, knobs, etc. while people with visual impairments have more trouble with signs and orientation.

The various problems of the different groups should then be assessed for the frequency and seriousness of the problems they cause. Reliable information on the incidence of barriers and serious human factors problems in the traveling population could help set priorities for further research.

The next stages would involve finding and evaluating cost-effective solutions to the most important problems. This could involve further studies of responses and perceptions of carefully selected representatives of the different groups.

It might be difficult for VIA Rail alone to undertake the scope of research required to assess the human factors for all of these special groups. Such studies would probably have to relate to all modes of transportation to ensure sufficient support for a thorough investigation of problems and solutions. Such work is necessary if we want to see that access to passenger services is not unreasonably limited by equipment design or service features.

5. STUDIES USING STATIONARY "MOCK-UPS" AND OPERATING "PROTOTYPES"

Probably the most valuable sorts of research, in terms of human factors considerations in designing new equipment, involves testing of proposed designs in a mock-up or prototype form. There is a series of steps with recursive loops involving selection, conceptual development, mocking-up, evaluation, re-design, re-testing, prototype development, prototype testing, and final design specification. These steps involve input from very many other sources, besides the human factors experts. Behavioural psychologists with human factors experience can play a major role in these design and testing studies.

At some stages the human factors input should be in the form of expert advice in the review of proposed designs and concepts. At other stages the human factors psychologist should play the major role in designing, conducting, and analyzing the studies of passengers' responses and perceptions. The relevant techniques here include individual testing and observation with mock-ups, in-depth discussions with groups of representative passengers, on-board observations, interviews and surveys.

Experience with testing mock-ups and prototypes can permit the most efficient conduct of these studies. It is often sufficient to have a rather reduced or simple representation of some feature and only a few subjects to test passengers' reactions. In other cases, however, the equipment or service concept must actually be tested in prototype form with large numbers of real, paying passengers on a running long-distance train. Knowing how much realism is required for valid and reliable results can save considerable research time and money.

6. "FINE-TUNING" STUDIES WITH NEW OPERATING EQUIPMENT

The final set of studies is required to see that the new equipment lives up to human factors requirements specified by previous studies. Surveys and observations of passengers, and some qualitative research with Focus Groups of passengers, can determine their comfort and satisfaction with the new equipment. Any unexpected problems will be determined from these studies and from systematic monitoring of feedback from service and maintenance staff.

The description above has, we hope, the familiar ring of "post-occupancy evaluation" which applied Psychologists have been practicing increasingly in recent years. In our view, it is the fine-tuning, not the evaluative component, which truly matters.

If there are unexpected human factors problems, possible "fixes" need to be evaluated with regard to those specific groups of passengers who are most likely to have problems.

The final product of this series of studies should be new long-distance passenger rail equipment for the Canadian market that meets the comfort and enjoyment needs of its passengers, while providing an economically and socially valuable service.

B. Gaps in Human-Factors Information

The next sections list the major remaining "anxieties of design" with regards to human factors of long-distance passenger trains. The questions are organized according to our taxonomy of passenger needs.

There are a few considerations which ought to be noted on every entry below. First, each entry should also contain the question, "... and how can people's behaviour be influenced." That's because it is not unreasonable to expect people to respond adaptively, if they know how. "Behavioural engineering" can be used as a gentle way of influencing people.

Second, factors interact but prose discussions can not do justice to such relations. Thus the kinds of clothing worn by customers influences temperature, comfort while napping, upholstery, willingness to slurp food from a lap tray, and so on.

Third, future research needs to deal with public sentiments as they evolve and to sense the trends as well as the existing status quo. Divining the future is perilous - of course - but good research methods can limit the risks.

Fourth, our concern throughout has been design information which leads to specific directions for hardware and service specification. In the discussion to follow, some issues are more attitudinal and some more corporeal. But, the end result is to develop equipment and services which achieve acceptable levels of human factors performance.

1. Environmental Variables

1.1 TEMPERATURE

a. What are desirable temperature regimes with regard to times of passenger boarding and alighting? Do you need extra heating in the winter and air conditioning in the summer for those times when the doors are opened and passengers are coming in and going out? How should the climate control equipment be programmed to deal with - or even anticipate -these transient situations?

b. What are the optimum comfort conditions for special populations such as elderly, young, or variously handicapped passengers?

c. What is the comfort/economy trade-off for these different groups at extreme ambient temperatures? For example, is it better to have cooler temperatures in summer for the sake of obese passengers with high rates of metabolism and provide blankets for slight, elderly persons with low metabolism or to have higher temperatures and some passengers uncomfortably warm?

1.2 AIR QUALITY

a. What groups are prevented from using the train by real or perceived allergies or sensitivity reactions?

b. What sorts of air filtering systems could satisfy various passenger requirements for air quality (eg. removal of smoke, odours, pollutants, pollen, dust)?

c. What are the positive and negative effects on passengers of various types of chemical air fresheners, ion exchangers, etc?

d. What effect would providing shower/change rooms for passengers have on air quality in coaches?

1.3 AUDITORY STIMULI

a. What sort of earphone/headset equipment would be optimum for train passengers? Does perceived hygiene pose difficult requirements to meet?

b. What sort of information or entertainment on headsets would passengers be willing to pay for? How much would they pay?

c. What information should be provided over a public address system? How should this information be presented to people with hearing impairments?

d. What kinds of noises are most bothersome to passengers? Can this be appended to I.S.O. standards? How is this affected by the behaviour which the noise interrupts?

1.4 VIBRATIONS

a. What are the effects of long-term vibration (from 8 hours to six days) on train passengers? Time periods up to 8 hours have received some study but the longer times have not been systematically investigated.

b. What are the possible long-term effects of exposure to vibration on a series of long train trips?

c. What specific sorts, or patterns, of vibratory stimuli are most bothersome? What patterns of vibration interfere most with writing, drinking, sleeping, etc.?

d. Would staggered wheel periodicities be helpful?

1.5 ACCELERATIONS

a. What are the acceleration and jerk tolerance limits for special groups (eg. new infants, elderly persons, people with physical problems such as cerebral palsy, spinal injury, sprained ankles, etc.?)

b. What potential passengers have balance problems that would make walking down the aisle on a moving train hazardous? Could any of these problems be avoided by an "acceleration warning device" ? If so, what is the optimum latency between signal and motion?

c. How does the timing of accelerations and jerks affect their potential for annoying or discomforting train passengers on a long trip?

1.6 LIGHTING

a. How does luggage rack design and placement affect optimum design and placement of reading lights? How does the design of beds, rooms, and roomettes affect light placement?

b. What is the passenger response to new materials for blocking solar infrared transmission into rail cars?

c. How do common visual problems, such as low light difficulties, affect requirements for night lighting in aisles, vestibules, etc?

1.7 SIGNS AND INFORMATION

a. What graphic representations are most understood and liked by the passengers in the viewing conditions found on the train?

b. How can bilingual signs be used and understood most effectively on the train? Should Behavioural Team's classic study on bilingualism be up-dated?

c. What new information systems (eg. videotex, dot matrix display, interactive computers, videotapes, etc.) would provide a cost-effective way to inform and entertain the passengers? How should these systems be implemented? What information and entertainment would be needed or appreciated?

d. How do the information needs of first-time or occasional rail travelers differ from the information needs of regular VIA Rail passengers? What is the best method of orienting new passengers to the rules, procedures, facilities, staff duties, etc?

1.8 OTHER VISUAL STIMULI

a. What aspects of the passing scenery would passengers on long-distance trains like to know about?

b. What kind of advertising, VIA posters, etc. should be employed? Where should they be placed to achieve optimum results in terms of passenger satisfaction and advertising or sales revenue?

c. What paint surfaces and colours can achieve the best mix of passenger satisfaction and easy, long-term maintenance?

d. In which areas of the train could perceptions of spaciousness be enhanced by using thin strips of highly polished metal trim? What placements and orientations are most effective in producing these perceptions?

e. Is passenger orientation and ease at night impaired by the use of smoked glass windows?

1.9 SPACE

There are general design recommendations for space needed by people, such as space for seating, walking, manoeuvering in a wheelchair, carrying luggage in the aisle, etc. They come from ergonomic guidelines for design of working and living spaces. But in light of VIA Rail economics.......

a. What are the effects of compromising different design dimensions to fit the unique design envelope of the train? Which dimensions would need to be compromised given different designs (eg. single vs double deck, or wheelchair access vs special carrier chair for the disabled)?

b. What portion of the population is affected by each clearance constraint? How does it interfere with their comfort or satisfaction?

c. What clothing do people wear on trains?

d. What are the statistics on luggage for today and the future?

1.9.1 PUBLIC SPACES

Space clearance dimensions, viewing angles, etc. are given in the literature for public spaces such as washrooms, observation decks, aisles, snack bars, and other public spaces.

a. How should these clearances and guidelines be incorporated into passenger train design?

b. What is the effect of the amount of public space vs accommodation space on perceptions of crowding? How does this differ for different passenger groups and different choices of accommodation space?

c. What sort of public spaces are most cost-effective for enhancing passengers' comfort and satisfaction on long train trips? How does this affect service and food plans?

1.9.2 ACCOMMODATION SPACES

There has been very little systematic study of passengers' responses to specific details of the accommodation spaces in long-distance trains.

a. What activities need to be supported by the design of the different accommodation spaces? For example, how many room vs 1st class coach vs 2nd class coach passengers want to eat, write, read, etc. in their accommodation space?

b. What does the composition of travel groups on long-distance train journeys in Canada indicate as the optimum mix of accommodations? What are the specific preferences of different segments of potential passengers for seating and sleeping space?

c. Can dedicated sleeping compartment cars (ie. no seats, primarily for overnight trip segments) be used sufficiently on any routes to justify their development? How does their likely acceptance relate to the development of management ulcers in scheduling and maintenance requirements?

1.9.2.1 SEATING

a. What would in-service tests of different seats indicate about optimum seating on a long rail journey? What differences in the seats and their spacing is required for enough passengers to be willing to pay an additional charge?

b. What are the advantages and disadvantages of different types of footrests (attached to your seat, attached to the seat in front of you, resting on the floor, vended by porter)?

c. What is the best combination, in the two classes, of seating for luggage storage, seat orientation and spacing, trays or tables, and seat reclining?

1.9.2.2 SLEEPING COMPARTMENTS

The recent psychological and ergonomic literature contains very little information about the design requirements for sleeping berths in trains (e.g., head clearance, space for changing clothes, access to upper berths, determinants of satisfactory sleep, etc.)

a. How do passengers react to different sleeping accommodations? How many of them would want to have the same accommodation on their next trip?

b. What would be required of the design for most passengers to be able to make and unmake the bed?

1.9.2.3 ROOMS AND ROOMETTES

a. Are there market segments that would pay for larger sleeping accommodations on overnight journeys?

b. What are the specific human factors involved in such activities as folding the bed and changing clothes in the roomette?

c. What special characteristics are in effect when a person or travel group occupies the same room or roomette for several consecutive days and nights?

d. Would Canadian passengers be willing to share sleeping compartments if the same level of privacy was provided as in the present upper and lower sections? Are there optimally bad cohort sizes? That is, are six people in a compartment the perfectly wrong size for balancing anonymity, security, social access, etc.?

1.9.2.4 MATERIALS AND FABRICS IN ACCOMMODATION SPACES

a. What are the ideal comfort, appeal, and maintenance properties for the various fabrics and materials used on the train? They include carpets, seat covers, armrest covers, food trays, wall and ceiling surface materials, bed upholstery or covering, sheets and blankets, disposable materials such as paper towels in the washrooms, etc.

b. Why does a "musty smell" develop in old upholstery and carpets and what specific maintenance treatments can be suggested?

c. What materials and applications are most likely to cause allergic or sensitivity responses in susceptible portions of the population?

2. Behavioural Variables

2.1 BOARDING AND LEAVING THE TRAIN

a. What are the specific human factors problems involved in boarding and alighting long-distance passenger trains? What are the problems of the fit population having to manage luggage, children, etc? What are the special problems of those with either minor or major physical disabilities?

b. How can design considerations (step height, handholds, level boarding, etc.) best solve these problems? What service factors are required? Can modern approaches to training help staff manage this additional service?

c. What special boarding and alighting problems occur with a double-deck design for long-distance passenger rail equipment?

2.2 LOCATING YOUR "TERRITORY" ON THE TRAIN

The factors affecting the choice of a room or roomette, or a first-class seat rather than a regular coach seat, have not received much study. These choices are generally made before passengers get on the train.

a. How do new passengers decide on a type of accommodation for their trip? How are their choices presented to them? Can today's VIA Rail passengers correctly identify their train options? Is that level of understanding good enough?

b. What factors affect the choice of accommodation by more experienced rail travelers?

c. How do different size and composition travel groups distribute themselves in an open coach with unreserved seats? If the number of seats facing each other in groups of four or six were limited to, say, 25%, would special measures be required to preserve them for larger travel groups?

d. Which passengers and situations require seat reservations? How do passengers find their reserved seat? How can patrons be "pre-informed" about coach seat availability before boarding? Can conductors be influenced to avoid using seating practices which help his or her train management but which are not beneficial to customers?

2.3 HANDLING LUGGAGE

a. What are the characteristics of luggage items carried onto Canadian long-distance trains? How does the number and size of items relate to characteristics of the passengers (eg. business versus holiday travelers)?

b. What is the best way to integrate luggage storage into the various accommodation spaces?

c. How do the human factors requirements of luggage handling differ for different portions of the traveling public? Are these differences consistently related to choice of accommodation?

d. Must VIA Rail accept any baggage smaller than an elephant (or any non-carry-on parcels) or risk losing passengers? Is high-level loading a solution?

2.4 ACTIVITIES IN THE ACCOMMODATION SPACE

2.4.1 SITTING

a. What are the passenger reactions to sitting in trains for long periods of time, especially when the seat also serves as sleeping accommodation? What are the various comfortable postures that can be adopted in different designs of seating?

b. After how many hours of sitting do passengers feel uncomfortable? How does this differ with characteristics of the passenger (eg. height, weight, age, etc.)?

c. What body parts experience sitting discomfort for different groups of possible passengers?

d. How does the seated reach ability of most passengers affect the placement of reading light controls?

2.4.2 RECLINING

a. What are the potential human factors problems with reclining seats of different types?

b. What angle of recline is optimal for sleeping comfort?

c. How does the design of foot and leg rests affect the design of reclining mechanisms?

d. What sort of reclining mechanism is best in terms of simplicity, reliability, and maintenance?

2.4.3 READING

a. What is the relative importance of reading on the train for different passengers and different lengths of journey?

b. What is the range of postures adopted for reading in the different accommodation and public spaces?

c. How does the range of postures and the size of reading material determine the optimum size and adjustability of reading lights?

d. What is the smallest print size and worst legibility of material which passengers might want to read on the train? What are the implications for reading light intensity?

e. In the near future, how many passengers will want to do some reading or will wish to work from a microcomputer which they bring along? What are the implications for tray, tables, and lights? For radio frequency interference?

f. What other devices might be used for "reading" on the train (eg. optical scanner, cassette recorder, portable braille device, etc.)?

2.4.4 TALKING AND SOCIAL INTERACTION

a. What type of passengers (business, holiday passengers, males, females, elderly) want to interact with their fellow passenger and which types do not?

b. What is the optimum distance limit for transmission of conversation in the various accommodation and public spaces on the train?

c. What sorts of talking and social interactions cause problems on long train journeys? What additional design features might ameliorate these problems?

d. Will correct acoustic masking techniques (as Behavioural Team are developing for new federal government offices) help privacy and ease acoustics standards for mechanical noise?

2.4.5 PLAYING GAMES

a. What is the likelihood of passenger acceptance of video games on long train journeys and what type of passenger would want to use them?

b. What other sorts of games would be appreciated by passengers? Could games, puzzles, cards, or toys be profitably handled by the snack bar? Can modern approaches to training help staff manage this additional service?

2.4.6 SIGHTSEEING

a. What is the best way to keep the windows clean on long train journeys? Are there any exterior design changes that would reduce the rate of dirt and spray accumulation on the outside windows?

b. Would passengers "be game" to clean their own window at a stop if they had access to a long-handled sponge and squeegee?

c. What is the best way to provide sightseeing information to passengers? Would a significant proportion purchase a guidebook with photos and descriptions of the scenery and points of interest (such as Capreol!) along the route?

d. What are the special sightseeing requirements of photographers? What sorts of pictures are possible and how much advance notice does the photographer need in order to take a picture (perhaps through the window) of some specific point of interest? How do different means of blocking solar heat gain through the windows affect photography on the train?

2.4.7 WORKING

Design specifications for work facilities on long-distance trains are needed to specify dimensions and other human factors related to passengers who want to work on board.

a. Should all or some roomettes be equipped with a chair and work table?

b. How large a conference room, if any, is recommended? What are the best spaces to be able to convert for conferencing, a room in a sleeping car, a section of the dining, lounge or snack bar car, a seating compartment, or the "Bistro Car" of fond memory?

c. What work-related equipment is likely to be needed on the train? Which of these should be provided by the train? Which should be supported by the design but provided by the passenger (eg. the train provides a desk and electrical outlet and the passenger provides a microcomputer)? What devices and tools should not be used on the train (eg. power hobby tools, two-way radios, etc.)?

2.4.8 SELF-CARE

a. What are the physical attributes of typical passengers in relation to the ergonomics of self-care in train roomettes? What sorts of self-care can be managed in other accommodation spaces? What public spaces (eg. washrooms) also serve self-care needs?

b. What are the preferences of passengers for compromising different spatial dimensions? For example, would passengers rather have more floor space or easier access to luggage?

c. What additional self-care features would be most appreciated by passengers, for example, showers, more washrooms, changing rooms, sale of toiletries on the train, places for unpacking and repacking bags, outlets capable of operating hair dryers or curling irons, or other special features?

2.4.9 CARE OF TRAVELLERS WITH SPECIAL NEEDS

a. What are the specific needs on Canadian long-distance trains for added facilities for the disabled (e.g., illuminated signs, handholds, wheelchair lifts, wider access doors)? Which of these features would help all of the train's passengers and which are useful to only a small portion of the disabled persons taking the train?

b. What sorts of disabilities now prevent persons from taking long trips on the train? What design changes could give these persons access to trains?

c. What are disabled passengers' subjective reactions to specially outfitted ("medicalized") rail cars? What new equipment can ensure that the needs of this special group of passengers is being properly met? What management problems would arise?

d. Can most problems of wheelchair accessibility be solved with limited lifts, tie-downs, and wheelchair accessible washrooms, with other areas on the train requiring use of a narrower push chair?

e. How could double-deck designs best deal with accessibility issues?

2.4.10 SLEEPING

a. What are the human factors characteristics of short naps on trains? When are passengers most likely to take a nap? What postures do they adopt? What design features contribute to comfort during these naps? What features contribute to discomfort either during or after a nap?

b. How do people respond to the first night or the first few nights of sleep in a train? How do reactions to this novel sleeping environment interact with other determinants of sleeping comfort?

c. Are there any special characteristics in the sleeping patterns and attitudes of long-distance train passengers? What information and/or experiences permit passengers to have a good anticipation of the accommodations they require to sleep overnight on the train? How can ticket sellers (including independent travel agents) convey the decision-supporting information to potential customers?

d. What are the consistent problems that passengers experience in sleeping in various train accommodations?

2.4.11 INTIMATE SOCIAL INTERACTIONS

a. What are the intimate social interactions that are the most bothersome to other passengers in terms of either their frequency or the degree of their offensiveness?

b. What sort of rules or social influences can reduce bothersome behaviours? Do clearly stated guidelines for behaviour help passengers to settle conflicts on their own? This might range from window shade adjustment to offensive food consumption. To what extent do passengers attribute culpability to VIA Rail for obnoxious behaviour on the part of other passengers (or crew!)?

c. What design features can reduce unacceptable behaviours, such as physical fighting?

d. What kinds of intimate social interactions should passengers be expected to tolerate on the part of their fellow passengers?

e. How much should the level of accommodation ("class") determine insulation from others' behaviour and privacy for your own behaviour?

f. Given specified operating noise levels, how much sound insulation is required in rooms and roomettes to provide privacy for intimacy, but permit cries for help to be heard?

2.4.12 SMOKING

a. What proportion of smoking passengers want to sit in a smoking area, and what proportion want to smoke occasionally but not sit in a smoking area?

b. What are the preferred or acceptable smoking places for those smokers who don't want to sit in a smoking section? How does smoking in these areas affect other passengers? What are the trends in public acceptance of smoking?

c. What proportion of non-smokers are satisfied to sit in a smoking area if they are with a companion who smokes, or if there are no other seats available? What proportion are mildly bothered by smoke and what proportion suffer extreme displeasure or physical sensitivity responses to second-hand smoke in the train environment?

d. How does the behaviour of the smoker and the composition of the smoke differ for cigarettes, cigars, and pipes? What are the implications for types of smoking permitted in different areas of the train, and for fire prevention?

2.5 TRANSITIONS BETWEEN ACCOMMODATION SPACE AND PUBLIC SPACE

a. What body movements and support are used getting into and out of seats? How does this differ depending on characteristics of the passenger? What additional handholds are needed?

b. When does discomfort arise because of the window passenger needing to get in or out past the aisle passenger? What methods do passengers usually employ to get through? What design changes could ease this transition?

c. What human factors or passenger expectation problems occur with the recent designs of automatic doors between cars? How might these problems be eliminated?

d. What is the best way to indicate to seated passengers whether the washrooms are occupied? Should the signal be based on the washroom door lock or some other indicator that someone is present in the washroom? Can subtle "behaviour engineering" be used to shorten toilet dwell times?

e. What is the best mechanism for doors to washrooms or doors to rooms? How should privacy curtains, screens for sleeping compartments, or other screens work?

f. Should any of the rooms be able to be locked from the outside by the passengers? What would be the best sort of "key" to unlock the room, standard key for all rooms, electronically recodable combination locks for each room, etc?

2.6 ACTIVITIES IN COMMON OR PUBLIC SPACES

2.6.1 AISLES

a. What situations cause congestion in the aisles on long-distance trains?

b. How does the design of luggage storage affect congestion when passengers are getting on and off of the train?

c. What safety and liability problems are caused for persons walking down the aisle by passengers or their belongings protruding into the aisle space?

d. What problems are the result of sway on the part of the passenger walking down the aisle, or objects being carried that protrude into the seating area?

2.6.2 WASHROOMS, TOILETS

a. How frequently do different types of passengers use the washroom? What is the average time spent in the toilet per person? How does this differ with the time of day, type of beverage service, and characteristics of the washroom?

b. How does the number of persons in toilet at the same time relate to toilet size? Is it better to have all single washrooms and changing rooms with no gender assignment, or separate men's and women's washrooms and changing rooms for more than one person?

c. What design features and cleaning schedule can optimize the perceived cleanliness of the washrooms? Can modern approaches to training help staff manage this additional service? What's the best way to keep the floor dry?

d. Are self-enclosed chemical toilets feasible on Canadian trains? If not, would it be advisable to lock (and later, to unlock) the washrooms or the flush mechanisms automatically in the stations?

e. What special air quality treatments would be beneficial in train washrooms?

f. What are the water requirements for different types of passengers and the different types of accommodations? How would this be affected by having showers on the train?

2.6.3 LOUNGES, SNACK BARS, AND RESTAURANTS

a. What level of food service is most cost-efficient in providing good quality food at reasonable prices?

b. What sorts of eating surface, seating, table covers, etc. are required for different types of food service facilities?

c. What other important functions, besides eating, can be served by restaurants, snack bars and lounges? Which of these functions occur simultaneously with eating and which are separate? How should the separate functions be scheduled into the use of the dining, lounge or snack bar car?

d. In light of recent court rulings, what safety, liability, or maintenance problems occur on the train because of alcohol consumption? How can these problems be avoided or reduced?

2.7 GENERAL PSYCHOLOGICAL CONSIDERATIONS

2.7.1 REGULATION OF HUMAN CONTACT

a. What situations result in unwanted human contact or closeness on long train trips? In which situations is the contact or closeness accidental, and in which is it intentional on the part of one or more of the passengers? What design, information, or service features could help in each of these situations?

b. What social problems on the train are related to alcohol or drug consumption? What measures can be taken to reduce these problems? In particular, what should be the relative role of social influence, of other passengers, and of train staff intervention in control of unwanted behaviour? How can passengers enlist support from other passengers or train staff members in dealing with an offensive drunk?

c. What design factors interfere with appropriate contact between friends or family members? Examples include fixed arm rests that prevent a child from lying on a parent's lap and beds that are not wide enough for two adults.

2.7.2 RELATION BETWEEN COST OF FURNISHINGS AND COMFORT

a. How well are different passengers able to "perceive" the relative or absolute cost of materials and furnishings? How well do passengers' affective reactions, in terms of comfort ratings, relate to the cost of furnishings? Which passengers are most influenced by the perceived cost of furnishings?

b. What difference in perceived cost of materials is appropriate for the different priced accommodations?

2.7.3 RELATION BETWEEN PERCEIVED CLEANLINESS AND COMFORT

a. What are the different cleanliness problems that could interfere with passengers' enjoyment of the train trip? How do passengers rate different areas of the train and different surfaces, materials, or fixtures in terms of the importance of their being clean? What additional measures are needed to ensure that the passengers' preferences for cleanliness are met?

b. What design features enhance the ease of maintaining optimally clean conditions?

c. How much garbage and trash is generated by different sorts of passengers? Would perceived cleanliness be enhanced if this garbage could be compacted for concealed storage until it can be dumped? What additional garbage facilities are necessary for items such as disposable diapers?

d. Are any laundry facilities or services needed on very long train journeys?

2.7.4 PERCEIVED AND ACTUAL SAFETY

a. What do passengers perceive as potential safety problems on the train? What do they consider to be the likelihood of various sorts of accidents? How do their perceptions compare to actual incidence and severity of accidents and mishaps involving passengers?

b. What behavioural safety features can be incorporated in the design of known "trouble spots" on the train?

c. What safety related information do passengers require for normal train operations? (Ideally, there should be no hazards involved in a normal trip and, therefore, no requirement for warnings.)

2.7.5 PHOBIAS, FEARS

a. What types of passengers are likely to have significant fears or phobias on the train? Are the stimuli that trigger the anxiety (eg. brake noises, lateral accelerations, the sight of other trains passing nearby) different depending on things such as age, sex, travel experience, or personality?

b. What are appropriate countermeasures for different sorts of fears or phobias? What sort of help can train staff offer, and what might other passengers be expected to do? What design features can reduce frightening stimuli?

2.7.6 STRESS REDUCTION

a. What are common stresses that passengers are experiencing when they begin a long-distance train trip? In particular, what is the relationship between other passenger variables (age, reason for the trip, socioeconomic factors, etc.) and type of stress symptoms experienced? What features of the train and trip can help decrease these symptoms?

b. What features of the train or trip can induce stress? Who are the susceptible passengers? What can be done to reduce their stress?

2.7.7 ENTERTAINMENT, FESTIVITIES

a. What is the extent of consumer demand in Canadian long-distance rail passenger service in terms of private parties, conferences, seminars, performances, film screenings, and other events for a select group of passengers?

b. What is the demand for entertainment of different sorts for the passengers in general?

c. What is the most cost-effective way to provide for these various entertainment needs?

2.7.8 SPECIAL TRAVEL GROUPS

a. Which special travel groups presently have adequate access to long-distance train travel and which groups do not? What barriers still remain for some travelers? What design or service changes could maximize accessibility?

b. What are appropriate policies and procedures for transporting unaccompanied children?

c. What special policies or procedures are required for other special travel groups such as senior citizens, groups of students, groups of sports fans, pregnant women, or persons with some disability?

2.7.9 TRAVELLING WITH PETS, VALUABLE LIVESTOCK

a. What are the preferences and requirements for the passengers traveling with their pets? What are appropriate guidelines for boarding, handling and treatment of pets by staff? What aspects of care are best taken care of by the passenger who owns the animal? What special issues arise when customers enter non-public areas?

b. Which animals should be allowed to be transported in the passenger areas and which should be carried in the baggage car? What extra considerations are necessary to transport valuable livestock, exotic pets, circus or zoo specimens, or other unusual creatures?

3. Interactions with Rail Personnel

3.1 IDENTIFYING HELP, INFORMATION, OR AUTHORITY FIGURES

a. What information and cues are presented to passengers to help them to identify train staff members? How are passengers informed as to the duties of the different staff members?

b. How does a passenger find the appropriate staff member when they need them? What would be the positive and negative effects of installing a call button on each seat? What characteristics should the call system have?

3.2 TRAINING AND DEMEANOR OF STAFF

a. What is the effect of the level and quality of training, and comportment of train staff, on passenger satisfaction and service complaints?

b. What special training do staff need about special travel groups, special situations, etc? Can modern approaches to training help staff manage this additional service?

3.3 EMERGENCY MANAGEMENT

a. What is the rate of occurrence of emergencies for individual passengers, and for more than one passenger? Which of these are minor and which are major emergencies? What mechanisms should be in place to deal successfully with whatever emergencies may arise?

b. What emergency related information should the passengers have before the trip, when an emergency close by is anticipated, and during an emergency?

BIBLIOGRAPHY

References are listed in alphabetical order under the main taxonomy headings. Many of the articles apply to more than one of the headings. Some, but not all, of these have been listed under more than one heading. Others are only listed under the most relevant heading or in the section of general references at the end.

1. General Environmental Variables

1.1 TEMPERATURE

Attia, M., Engel, P., and Hildebrandt, G. "Quantification of Thermal Comfort Parameters Using a Behavioural Indicator." Physiology and Behaviour, 1980, 24(5), 901-910.

Barkow, B., and Clark, G.A. "Human Factors in Vehicle Design." In R.M. Soberman and H.A. Hazard (Eds.), Canadian Transit Handbook. Toronto, Ontario: University of Toronto - York University, January 1980.

Baumgartner, G. "The Vienna-Arsenal Vehicle Testing Installations." Eisenbahntechnik, Vienna, 1982, 2, 5-10.

Eberlein, D. "Modal Split of Passenger Traffic in Japan." Deutsche Forschungs und Versuchsanstalt fur Luft und Raumfahrt, Koln, 1982.

Faast, F. "Tests on Air-Conditioned Rolling Stock." Eisenbahntechnik, Vienna, 1982, 2, 12-16.

Fanger, P.O. "Local Discomfort to the Human Body Caused by Non-Uniform Thermal Environments." Annals of Occupational Hygiene, 1977, 20, 285-291.

Hawes, A. "Recent Progress and Future Development on British Railways Suburban Stock." Passenger Environment, The Institute of Mechanical Engineers, 1972.

Hawkins, L.H. "The Influence of Air Ions, Temperature and Humidity on Subjective Well-Being and Comfort." Journal of Environmental Psychology, 1981, 1(4), 279-292.

Heimo, M., Ketola, R., Makela, P., Makinen, R., Niemela, R., Starck, J. and Partanen, T. "Work Conditions and Health of Locomotive Engineers Part 1: Noise, Vibration, Thermal Climate Diesel Exhaust Constituent Ergonomics." Scandinavian Journal of Work, Environment and Health, 1979, 4(3), 3-14.

Humphreys, M.A. "Environmental Temperature and Thermal Comfort." Building Services Engineer, July 1974, 42, 77-81.

Hutcheon, N.B. "Thermal Environment and Human Comfort." Canadian Building Digest, National Research Council Division of Building Research, 1968, 102.

International Union of Railways Office for Research and Experiments, "Unification of Air Conditioning and Electrical Equipment in Coaches. Evaluation of the Tests Carried Out to Determine the Optimum Air Circulation and Temperature Distribution in a Couchette Compartment." Oudenoord 60, Utrecht, Netherlands, October 1979.

Jacobson, I.D., Richards, L.G. and Kuhlthau, A.R. "Models of Human Comfort in Vehicle Environments." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Kaiser Engineers, "Subway Environmental Design Criteria." Springfield, Va., September 1971.

MacPherson, R.K. "Thermal Stress and Thermal Comfort." In A.T. Welford (Ed.), Man Under Stress. New York: Wiley & Sons, 1974.

Molinari, H.H., Greenspan, J.D. and Kenshalo, D.R. "The Effects of Rate of Temperature Change and Adapting Temperature on Thermal Sensitivity." Sensory Processes, 1977, 1(4), 354-362.

Oborne, D.J. "Passenger Comfort: An overview." Applied Ergonomics, 1978, 9(3), 131-136.

Parker, J.C. "Airconditioning Related to Passenger Environment." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Pichler, H. and Tomsu, P. "The Use of Microprocessors for the Air Condition Control in Railway Coaches." ZEV - Glasers Annalen, February/March 1982, 106(2/3), 122-127.

Ravel, J. and Bernard J.P. "Future Internal Service Coaches of the S.N.C.F." French Railway Techniques, 1975, 18(2), 37-56.

Rohles, F.H. "Thermal Comfort and Strategies for Energy Conservation." Journal of Social Issues, 1981, 37(2), 132-149.

Rohles, F.H. "Preference for the Thermal Environment by the Elderly." Human Factors, 1969, 11(1), 37-41.

Singleton, W.T. "Introduction to Ergonomics." Geneva: World Health Organization, 1972.

Specht, D. "The Air-Conditioning Equipment of the R1C WLX Sleeper." Schienenfahrzeuge, Berlin, September 1981, 25(5), 225-228.

Spring, K.H. "Research and Design with Particular Reference to the Advanced Passenger Train." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Sternat, P. "Air Conditioning in the New SNCF Compartment Coaches." Revue Generale du Froid, Paris, November 1981, 11,573-583.

Temming, J. "Comfort Requirements for Heating, Ventilation and Air Conditioning in Motor Vehicles." In D.J. Oborne, and J.A. Levis (Eds.), Human Factors in Transport Research, New York and London: Academic Press, 1980.

Temming, J. and Hucho, W.H. "Passenger-Car Ventilation for Thermal Comfort (ASM)." Society of Automotive Engineers Inc., Society of Automotive Engineers Technical Paper Series, 1979.

Ujcic, J. "Comfort - An Aspect of Passenger Service Quality." Zeleznice, Beograd, September 1982, 38(9), 17-26.

Walker, P.J. "America's Standard Tramcar Specification." Modern Tramway, October 1973, 349-352.

Wilcock, H. "Recent Progress and Future Developments in British Railways Mainline Stock." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Young, J.A. "Passenger Comfort in Urban Transit Vehicles: A State of the Art Report." Ontario Ministry of Transportation and Communications, January 1976.

No Author "Erogonomics Around the World, Ergonomics in Brazil: Research, Practical Considerations." Arquivos Brasileiros de Psicologia Aplicada, January-March 1975, 27(1).

No Author "Maintaining a service in the ice and snow." International Railway Journal, February 1983, 23(2), 34 and 36-38.

No Author "Optimization of the Temperature in Corail Coaches." Document Technique OREDT 127 (B108) Utrecht, April 1981, 1.

No Author "Passenger Comfort in Urban Transit Vehicles - A State of the Art Report." Ontario Ministry of Transportation and Communications, Research and Development Division, January 1976.

No Author "Three Railways Adapt to High Temperatures." International Railway Journal, Febuary 1983, 23(2), 38-40.

1.2 AIR QUALITY

Dayman, Jr., B., Holway, H.P., Hammitt, A.G., Tucker, C.E., Curtis, E. and Vardy, A.E. "Alleviation of Pressure Pulse Effects for Trains Entering Tunnels." Urban Mass Transportation Administration, Report No. DOT/TSC, UMTA-79/28, June 1979.

Fujii, S.A. "A Research Report on the Improvement of Air Circulation Inside a Railway Carriage." Clean Air, Japan, April 1969, 7(1), 4-31.

Gribanov, O.I., Gofmekler, V.A., Alpeev, A.V., and Gerasimova, I.E. "Approaches to the Establishment of Hygienic Standards for Air Pollutants in Passenger Cars and at Railway Stations." Gigiena and Sanitar, 1980, 17-19.

Jacobson, I.D., Richards, L.G. and Kuhlthau, A.R. "Models of Human Comfort in Vehicle Environments." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Lakshin, A.M. "Some Hygienic Aspects of Passenger Transportation by Railroad." Gigiena and Sanitar, 1980, 0(4), 66-68.

Lakshin, A.M. and Novoselov, V.P. "Physiological Reactions of the Passenger to Transportation Conditions." Gigiena and Sanitar, 1979, 0(9), 84-85.

Oborne, D.J. "Passenger Comfort - An Overview." Applied Ergonomics, 1978, 9(3), 131-136.

Parker, J.C. "Airconditioning Related to Passenger Environment." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Temming, J. "Comfort Requirements for Heating, Ventilation and Air Conditioning in Motor Vehicles." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Temming, J. and Hucho, W.H. "Passenger-Car Ventilation for Thermal Comfort (ASM)." Society of Automotive Engineers Inc., Society of Automotive Engineers Technical Paper Series, 1979.

Tom, G., Poole, M.F., Galla, J. and Berrier, J. "The Influence of Negative Air Ions on Human Performance and Mood." Human Factors, 1981, 23(5), 633-636.

Vardy, A.E. "Elimination of Pressure Transients on a Single Train in a Railway Tunnel." Journal of Advanced Transportation, 1979, 13(3), 61-83.

Wilcock, H. "Recent Progress and Future Developments in British Railways Mainline Stock." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Young, J.A. "Passenger Comfort in Urban Transit Vehicles: A State of the Art Report." Ontario Ministry of Transportation and Communications, January 1976.

No Author "Is Diesel Engine Exhaust Harmful?" Health Effects of Exposure to Diesel Exhaust - Impacts of Diesel-Powered Light-Duty Vehicles by National Research Council, Washington, D.C., 1981.

No Author "Unification of Air-Conditioning and Electrical Equipment in Coaches." International Union of Railways Office for Research and Experiments, Utrecht, Netherlands, October 1979.

1.3 AUDITORY STIMULI

Barkow, B. and Clark, G.A. "Human Factors in Vehicle Design." In R.M. Soberman and H.A. Hazard (Eds.), Canadian Transit Handbook. Toronto, Ontario: University of Toronto - York University, January 1980.

Broadbent, D.E. "Effects of Noise on Behaviour." In C.M. Harris (Ed.), Handbook of Noise Control. New York: McGraw-Hill, 1957.

Bruel, P.V. Noise: Do we measure it correctly? Bruel and Kjaer A/S, Naerum, Denmark, 1975.

Bryan, M.E. and Tempest, W. "Factors Affecting the Level of Noise Inside Motor Cars." In D.J. Oborne and D.J. Levis (Eds.), Human Factors in Transport Research, Volume 2. New York, London: Academic Press, 1980.

Callow, G.D. "Subjective Response to Outdoor and Indoor Traffic Noise." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Clevenson, S.A. "Subjective Response to Combined Noise and Vibration During Flight of a Large Twin-Jet Airplane." NASA Technical Memo TM X - 3406, National Aeronautics and Space Administration. Washington, D.C., October 1976.

Cohn, L.F. and McVoy, G. Environmental Analysis in Transportation Systems. New York: John Wiley and Sons, 1981.

Dempsey, T.K. and Leatherwood, J.D. "Prediction of Passenger Ride Quality in a Multifactor Environment." NASA Technical Memo TMX - 73945, National Aeronautics and Space Administration, September 1976.

Dunn, J.W. and Mills, B. "Prediction of Low Frequency Sound Pressure Distribution Inside Vehicle Passenger Compartment from its Structural Dynamic Response." Journal of the Society of Environmental Engineers, 1980, 19(3), 11.

Fields, J.M. and Walker, J.G. "Comparing the Relationship Between Noise Level and Annoyance in Different Surveys: A Railway Noise vs Aircraft and Road Traffic Comparison." Journal of Sound and Vibration, 1982, 81(1), 51-80.

Glass, D.C. and Singer, J.E. "Experimental Studies of Uncontrolled and Unpredictable Noise." Representative Research in Social Psychology, January 1973, 4(1).

Glass, D.C. and Singer, J.E. Urban Stress. New York: Academic Press, 1972.

Harris, C.M. (Ed.) Handbook of Noise Control. Second Edition. New York: McGraw-Hill Book Company, 1979.

Heino, M., Ketola, R., Makela, P. Makinen, R., Niemela, R., Starck, J. and Partanen, T. "Work Conditions and Health of Locomotive Engineers. Part 1. Noise Vibration, Thermal Climate, Diesel Exhaust Constituents Ergonomics." Scandinavian Journal of Work, Environment and Health, 1979, 4(3), 3-14.

Hill, R.F. and Garratt, C.H. "The Mark III Sleeping Cars." Institution of Mechanical Engineers, Proc. 1982, 196(12), 87-94.

Hillquist, R.K. "Sound Measurement Standards for Surface Transportation Vehicles." Noise Control Engineering, 1979, 12(3), 131.

Hughes, J. "Turning Down the Volume." Environmental Views, 1981, 4(3), 27-29.

Ikeda, S. and Von Winterfeldt, D. "Standards Against Noise Pollution: The Case of Shinkansen Trains in Japan." Journal of Environmental Management, 1982, 14(1), 3-16.

Jacobson, I.D. and Barber, R.W. "Comparison of Passenger-Comfort Models in Buses, Trains and Airplanes." Transportation Research Record 646, Transportation Ride Quality. Washington, D.C.: National Academy of Science, 1977.

Jacobson, I.D., Richards, L.G. and Kuhlthau, A. R. "Models of Human Comfort in Vehicle Environments." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Kahneman, D. Attention and Effort. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1973.

Kryter, K.D. The Effects of Noise on Man. New York: Academic Press, 1970.

Leatherwood, J.D., Dempsey, T.K. and Clevenson, S.A. "A Design Tool for Estimating Passenger Ride Discomfort Within Complex Ride Environments." Human Factors, June 1980, 22(3), 291-312.

Lippmann, S.A. and Oblizajek, K.L. "Tire Noise Sensed in Passenger Cars - Characteristics, Sources, Strategies for Control." Inter-Noise 80, Miami, 1980, Vol.1.

Lotz, R. and Kurzweil, L.G. "Rail Transportation Noise." In C.M. Harris (Ed.) Handbook of Noise Control. New York: McGraw-Hill, 1979.

Malone, R. "CTA Cars: No Frills, No Nonsense." Railway Age, May 10, 1982, 22-23.

Oborne, D.J. "Examples of the Use of Rating Scales in Ergonomics Research." Applied Ergonomics, December 1976, 7, 201-204.

Priest, J. "Synthesized Speech: Ergonomic Implications for the Transportation Industry." In A.D. Seidel and S. Danford (Eds.), Environmental Design: Research, Theory and Application. Proceedings of the 10th Annual Conference of the Environmental Design Research Assoc., Washington, D.C., 1979.

Reim, B., Glass, D.C. and Singer, J.E. "Behavioural Consequences of Exposure to Uncontrollable and Unpredictable Noise." Journal of Applied Psychology, 1971, 1(1), 44-56.

Reybardy, H. "Method of Measuring and Establishing the Level of Acoustic Comfort in Coaches." Revue Generale des Chemins de Fer, September 1982, 191, 641-650.

Sandler, S. "The Intangible Appeal of Light Rail: An Overview and Call for Research." Northern Virginia Community College. Unpublished Paper.

Schoultz, M.B. and Snyder, W.J. "Passenger Perceptions of the Helicopter: Ride-Quality Considerations." Transportation Research Record 646, Transportation Ride Quality. Washington, D.C.: National Academy of Science, 1977.

Singleton, W.T. "Introduction to Ergonomics." World Health Organization, Geneva 1972.

Solomon, K.M., Solomon, R.J. and Silien, J.S. "Passenger Psychological Dynamics." U.S. Department of Transportation, Contract H-804, June 1968.

Sommer, H.C. and Harris, C.S. "Combined Effects of Noise and Vibration on Mental Performance as a Function of Time of Day." Aerospace Medicine, May 1972, 43(5), 479-482.

Spring, K.H. "Research and Design with Particular Reference to the Advanced Passenger Train." Passenger Environment, The Institute of Mechanical Engineers, London, 1972.

Stanworth, C.G. "Consideration of Some Noise Sources Due to Railway Operation." Journal of Sound and Vibration, 1983, 87(2), 233-239.

Stusnick, E., et al "Handbook for the Measurement Analysis and Abatement of Railroad Noise." Wyle Laboratories, Report No. WR81-10, January 1982. U.S. Federal Railroad Administration, Report No. FRA/ORD-82/02H.

Tempest, W. and Bryan, M.E. "The Effects of Vehicle Noise on Health and Driver Performance." In D.J. Oborne, and J.A. Levis, (Eds.), Human Factors in Transport Research Vol. 2. London, England: Academic Press, 1980.

Ten Wolde, T. and van Ruiten, C.J.M. "Sources and Mechanisms of Wheel/Rail Noise: State-of-the-Art and Recent Research." Journal of Sound and Vibration, 1983, 87(2), 147-160.

Toepfer, K. and Vol'fson, A.L. "Efficiency of Sound-Proofing on High Speed Trains." DET-Die Eisenbahntechnik, Berlin, 1981, 29(11), 456-457.

Walker, J.G. and Fields, J.M. "Reactions to Railway Noise in Great Britain: An Updated Report." Inter Noise 80, (2), 1980, Noise Control Foundation, P.O. Box 3469, Arlington Branch, Poughkeepsie, N.Y. 12603.

Welford, A.T. "Signal, Noise, Performance, and Age." Human Factors, 1981, 23(1), 97-109.

Wichansky, A.M. The Effects of the Ride Environment on Intercity Train Passenger Activities. Washington: Transportation Research Board Meeting, 1979.

Wilcock, H. "Recent Progress and Future Development in British Railways Main-Line Stock." Passenger Environment, The Institute of Mechanical Engineers, London, 1972.

Williams, C.E., Stevens, K.N. and Klatt, M. "Judgments on the Acceptability of Aircraft Noise in the Presence of Speech." Journal of Sound and Vibration, 1969, 9(2), 263-275.

Williams, D. and Tempest, W. "Measurement and Subjective Assessment of Noise in Motor Vehicles." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Yamanaka, K., Nakagawa, T., Kobayashi, F., Kanada, S., Tanahashi, M., Muramatsu, T. and Yamada, S. "Hygienic Studies of the Shinkansen Super Express Railway Noise and Vibration in Residential Areas." Department Public Health, Nagoya University, 1980.

Yokoo, Y. and Sebayashi, T. "Effects of Chronic Exposure to Railway Noises on the Thinking Process of School Children." Japanese Journal of Hygiene, 1981, 35(6), 841-850.

Young, J.A. "Passenger Comfort in Urban Transit Vehicles: A State of the Art Report." Ontario Ministry of Transportation and Communications, January 1976.

No Author "Proceedings of the Workshop on Railway and Tracked Transit System Noise, 2nd, 1978." Journal of Sound and Vibration, October 3, 1979, 66(3), 295-506.

No Author "Railway Passenger Comfort - Developments in Seating and Noise Suppression for Vehicles in Tropical and Temperate Climates." Railway Gazette, September 18, 1964.

1.4 VIBRATIONS

Allen, G.R. "Vibration Requirements for Ride Quality: Recent Progress and Trends." In Transportation Research Record 894 - Evaluation and Measurement of Ride Quality: State-of-the-Art Report. Transportation Research Board, National Research Council, National Academy of Sciences, Washington, D.C., 1982.

Barwell, F.T. "Passengers' Reaction to Vibration." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Clevenson, S.A. "Subjective Response to Combined Noise and Vibration During Flight of a Large Twin-Jet Airplane." NASA Technical Memo TMX-3406, National Aeronautics and Space Administration. Washington, D.C., October 1976.

Cooper, D.R.C. and Young, J.C. "Road Surface Irregularity and Vehicle Ride." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Corbridge, C., Griffin, M.J. and Levis, J.A. "Laboratory Study of Truck Ride: Validation of Subjective Judgements Obtained in the Field." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Dempsey, J.K. "A Model and Predictive Scale of Passenger Ride Discomfort." NASA Technical Memo TMX-72623, National Aeronautics and Space Administration, December 1974.

Dempsey, T.K. and Leatherwood, J.D. "Prediction of Passenger Ride Quality in a Multifactor Environment." NASA Technical Memo TMX-73945, National Aeronautics and Space Administration, September 1976.

Dempsey, T.K. and Leatherwood, J.D. "Methodological Considerations in the Study of Human Discomfort to Vibration." NASA Langley Research Center, Hampton Virginia. Presented at the International Conference on High-Speed Ground Transportation, Tempe Arizona, January 7-10, 1975.

Dempsey, T.K. and Leatherwood, J.D. "Experimental Studies for Determining Human Discomfort Response to Vertical Sinusoidal Vibration." NASA Technical Note TND-8041, National Aeronautics and Space Administration, November 1975.

Grether, W.F., Harris, C.S., Mohr, G.C., Nixon, C.W., Ohlbaum, M., Sommer, H.C., Thaler, V.H. and Veghte, J.H. "Effects of Combined Heat, Noise and Vibration Stress on Human Performance and Physiological Functions." Aerospace Medicine, 1971, 42, 1092-1097.

Griffin, M.J., Parsons, K.C. and Whitham, E.M. "Vibration and Comfort 4. Application of Experimental Results." Ergonomics, 1982, 25(8), 721-740.

Griffin, M.J., Whitham, E.M. and Parsons, K.C. "Vibration and Comfort 1. Translational Seat Vibration." Ergonomics, 1982, 25(7), 603-630.

Guignard, J.C., Majewski, P.L. and Muzzy, W.H. "Determining Thresholds of Human Response to Vibration Using Acceleration Sweeps at Constant Frequency." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Harris, C.M. and Crede, C.E. (Eds.) Shock and Vibration Handbook. New York: McGraw-Hill, 1976.

Healey, A.J. "Assessment of Ride Quality of AIRTRANS System." Transportation Research Record 646, Transportation Ride Quality. Washington, D.C.: National Academy of Science, 1977.

Healey, A.J. "Digital Processing of Measured Vibration Data for Automobile Ride Evaluation." In A. Berman and A.J. Hannibal (Eds.), Passenger Vibration in Transportation Vehicles AMD, Volume 24. The American Society of Mechanical Engineers, 1977.

Heino, M., Ketola, R., Makela, P., Makinen, R., Niemela, R., Starck, J. and Partanen, T. "Work Conditions and Health of Locomotive Engineers. Part I. Noise, Vibration, Thermal Climate, Diesel Exhaust Constituent Ergonomics." Scandinavian Journal of Work, Environment and Health, 1979, 4(3), 3-14.

Higginbotham, R. "Ride-Quality Evaluation and Technology in Intercity Rail Passenger Car Specifications." In Transportation Research Record 894 - Evaluation and Measurement of Ride Quality: State-of-the-Art Report. Transportation Research Board, National Research Council, National Academy of Sciences, Washington, D.C., 1982.

Irwin, A.W. "Perception Comfort and Performance Criteria for Human Beings Exposed to Whole Body Pure Yaw Vibration and Vibration Containing Yaw and Translational Components." Journal of Sound and Vibration, 1981, 76(4), 481-498.

Leatherwood, J.D. "Vibrations Transmitted to Human Subjects Through Passenger Seats and Considerations of Passenger Comfort." NASA Technical Note TND-7929, National Aeronautics and Space Administration, Washington, June 1975.

Leatherwood, J.D. and Dempsey, T.K. "Psychophysical Relationships Characterizing Human Response to Whole-Body Sinusoidal Vertical Vibration." NASA Technical Note TND-8188, National Aeronautics and Space Administration, June 1976.

Leatherwood, J.D., Dempsey, T.K. and Clevenson, S.A. "A Design Tool for Estimating Passenger Ride Discomfort within Complex Ride Environments." Human Factors, June 1980, 22(3), 291-312.

Levis, J.A. and McKinlay, W.P. "A Quantification of Subjective Judgements of Vehicle Ride." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Li, W.H. "Problems of Acceleration and Vibration Related to Passenger Comfort and Safety in Urban Mass Transportation. Part I. Categorization of Passenger Effects." Technical Paper 5. Urban Mass Transportation Administration, U.S. Department of Transportation, November 1972.

Liu, H.W. "Problems of Acceleration and Vibration Related to Passenger Comfort and Safety in Urban Mass Transportation. Part II. The Reaction of Muscle to a Dynamic Load." Technical Paper 6. Urban Mass Transportation Administration, U.S. Department of Transportation, November, 1972.

Oborne, D.J. "Passenger Comfort: An Overview." Applied Ergonomics, 1978, 9(3), 131-136.

Oborne, D.J. "Vibration and Passenger Comfort - Can Data from Subjects Be Used to Predict Passenger Comfort?" Applied Ergonomics, 1978, 9(3), 155-161.

Oborne, D.J. "Vehicle Vibration and Passenger Comfort." Ergonomics, 1977, 20(5), 558.

Oborne, D.J. "Vibration and Passenger Comfort." Applied Ergonomics, 1977, 8(2), 97-101.

Oborne, D.J. "A Critical Assessment of Studies Relating Whole-Body Vibration to Passenger Comfort." Ergonomics, 1976, 19, 751-774.

Oborne, D.J. and Humphreys, D.A. "Individual Variability in Human Response to Whole-Body Vibration." Ergonomics, 1976, 19, 719-726.

Ohlbaum, M.K., O'Briant, C.R. and Van Patten, R.E. "The Effect of Viewing Distance on the Visual Decrements Associated with Vibration." American Journal of Optometry, 1971, 48, 298-306.

Parsons, K.C. and Griffin, M.J. "Vibration and Comfort 2. Rotational Seat Vibration." Ergonomics, 1982, 25(7), 631-644.

Parsons, K.C. and Griffin, M.J. "A Method for Predicting the Effects of Vehicle Vibration on Passenger Comfort." Ergonomics, 1980, 23(5), 518.

Parsons, K.C. and Griffin, M.J. "Predicting the Vibration Discomfort of Seated Passengers." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research. Vol.2. London, England: Academic Press, 1980.

Parsons, K.C., Griffin, M.J. and Whitham, E.M. "Vibration and Comfort 3. Translational Vibration of the Feet and Back." Ergonomics, 1982, 25(8), 705-720.

Richardson, J. and Stroud, P.C. "Passenger Requirements in an Automated Transport System." Transport and Road Research Laboratory, Berkshire, England, 1975, Report No. NSR1.

Roll, J.P., Martin, B., Gauthier, G.M. and Ivaldi, F.M. "Effects of Whole Body Vibration on Spinal Reflexes in Man." Aviation, Space and Environmental Medicine, 1980, 51(11), 1227-1233.

Sandler, S. "The Intangible Appeal of Light Rail: An Overview and Call for Research." Northern Virginia Community College, Unpublished Paper.

Sayers, M.W. and Hedrick, J.K. "Track Maintenance / Rail Car Suspension Trade-Offs to Obtain Acceptable Ride Quality." In A. Berman and A.J. Hannibal (Eds.), Passenger Vibration in Transportation Vehicles, AMD, Volume 24. New York: The American Society of Mechanical Engineers, 1977.

Scheibe, W. and Rohmert, W. "Evaluation of Human Strain During Interrupted Exposure to Vibration." European Journal of Applied Physiology and Occupational Physiology, 1980, 42(4), 209-226.

Schoultz, M.B. and Snyder, W.J. "Passenger Perceptions of the Helicopter: Ride-Quality Considerations." Transportation Research Record 646, *Transportation Ride Quality.* Washington, D.C.: Academy of Science, 1977.

Solomon, K.M., Solomon, R.J. and Silien, J.S. "Passenger Psychological Dynamics." U.S. Department of Transportation, Contract H-804, June 1968.

Sommer, H.C. and Harris, C.S. "Combined Effects of Noise and Vibration on Mental Performance as a Function of Time of Day." Aerospace Medicine, May 1972, 43(5), 479-482.

Stephens, D.G. "Comparative Vibration Environments of Transportation Vehicles." In A. Berman and A.J. Hannibal (Eds.), *Passenger Vibration in Transportation Vehicles AMD, Volume 24.* The American Society of Mechanical Engineers, 1977.

Wambold, J.C. and Park, W.H. *Objective Measures of Ride Quality for Railroads.* University Park, Pa: The Pennsylvania Transportation Institute, April 1979.

Wambold, J.C. and Park, W.H. "Ergonomic Simulator Aids Car, Transportation Vehicle Design." Technical Information Service, National Research Council, July 1976.

Wichansky, A.M. "Effects of the Ride Environment on Passenger Activities: A Field Study on Intercity Trains." Washington: U.S. Department of Transportation, January 1979.

Wichansky, A.M. "The Effects on the Ride Environment on Intercity Train Passenger Activities." Washington: Transportation Research Board Meeting, 1979.

Yamanaka, K., Nakagawa, T., Kobayashi, F., Kanada, S., Tanahashi, M., Muramatsu, T. and Yamada, S. "Hygienic Studies of the Shinkansen Super Express Railway Noise and Vibration in Residential Areas." Department Public Health, Nagoya University, 1980.

No Author "Guide for the Evaluation of Human Exposure to Whole-Body Vibration." International Organization for Standardization, International Standards ISO Handbook 4, *Acoustics, Vibration and Shock.* 1978.

No Author "Mechanical Vibration and Shock." Technical Committee 108, Revision of Document 1SO ITC108 WG 7 (Secr.17). Germany, December 1968.

1.5 ACCELERATIONS

Abernethy, C.N. and Jacobs, H.H. "Effects of Deceleration and Rate of Deceleration on Line Seated Human Subjects." Transportation Ride Quality, Transportation Research Board. TRR 646, U.S., 1977.

Barkow, B. and Clark, G.A. "Human Factors in Vehicle Design." In R.M. Soberman and H.A. Hazard (Eds.), *Canadian Transit Handbook.* Toronto, Ontario: University of Toronto - York University, January 1980.

Browning, A.C. "The Tolerance of the General Public to Horizontally Accelerating Floors, with Special Reference to Pedestrian Conveyors." Ministry of Defence, Farnborough, Hants, England, Royal Aircraft Establishment Technical Report 71105, 1972.

Elmarghy, W.M., Gaiser, J.A. and Bexon, H.J. "The LRC Coach Trucks and Suspension." American Society of Mechanical Engineers, New York, Report No. 79-RT-4, January 1979.

Garbe, J. "Effects of Acceleration on People." Aerztliche Dienst der DB, July 1975, 36(7-8), 96-100.

Guignard, J.C., Majewski, P.L. and Muzzy, W.H. "Determining Thresholds of Human Response to Vibration Using Acceleration Sweeps at Constant Frequency." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Hay, W.W. Railroad Engineering. Second Edition. New York: John Wiley and Sons, 1982.

Jacobson, I.D. and Barber, R.W. "Comparison of Passenger-Comfort Models in Buses, Trains and Airplanes." Transportation Research Record 646, Transportation Ride Quality. Washington, D.C.: Academy of Science, 1977.

Jacobson, I.D., Richards, L.G. and Kuhlthau, A.R. "Models of Human Comfort in Vehicle Environments." In D.J. Oborne and J.A. Levis (Eds), Human Factors in Transport Research. Vol 2. London, England: Academic Press, 1980.

Li, W.H. "Problems of Acceleration and Vibration Related to Passenger Comfort and Safety in Urban Mass Transportation. Part 1 - Categorization of Passenger Effects." Technical Paper #5. Urban Transportation Institute, Syracuse University, N.Y., November 1972.

Liu, H.W. "Problems of Acceleration and Vibration Related to Passenger Comfort and Safety in Urban Mass Transportation. Part II - The Reaction of Muscle to a Dynamic Load." Technical Paper #6. Urban Transportation Institute, Syracuse University, N.Y., November 1972.

Pepler, R.D., Sussman, E.D. and Richards, L.G. "Passenger Comfort in Ground Vehicles." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research. Vol 2. London, England: Academic Press, 1980.

Richards, L.G. "Time Dependence and Temporal Information Integration for Human Reaction to Motion." Ergonomics, November 1978, 21(11), 913-923.

Rinalducci, E.J. "Effects of Aircraft Motion on Passengers' Comfort Rating and Response Times." Perceptual and Motor Skills, February 1980, 50(1), 91-97.

Spring, K.H. "Research and Design with Particular Reference to the Advanced Passenger Train." Passenger Environment, The Institute of Mechanical Engineers, London, 1972.

No Author "Guide for the Evaluation of Human Exposure to Whole-Body Vibration." International Organization for Standardization, International Standards ISO Handbook 4, Acoustics, Vibration and Shock. 1978.

No Author "Linear Dynamics of Railway Vehicles." Associacion de Investigacion del Transporte, May 1980.

1.6 LIGHTING

Ball, J. and Mathias, R. "Lighting Trends Over the Next Twenty Years." Engineering Digest, October 1980.

Bedwell, C.H. "Eye, Vision and Visual Discomfort." In I. Easson (Ed.), Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Boyce, P.R. Human Factors in Lighting. London: Applied Science Publishers, 1981.

Bruel, P.V. "Noise, Do We Measure It Correctly?" In A. Berman and A.J. Hannibal (Eds.), Passenger Vibration in Transportation Vehicles AMD, Volume 24. The American Society of Mechanical Engineers, 1977.

Brundrett, G.W. "Human Sensitivity of Flicker." In I. Easson (Ed.), Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Chaikin, A.L., Derlega, V.J. and Miller, S.J. "Effects of Room Environment on Self-Disclosure in a Counselling Analogue." In I. Easson (Ed.), Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Champness, B. "Some Strange Effects of Fluorescent Lighting on Social-Behavior." In I. Easson (Ed.), Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Cockram, A.H., Collings, K.B. and Langdon, F.J. "Study of User Preferences for Fluorescent Lamp Colors for Daytime and Night-time Lighting." In I. Easson (Ed.), Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Collins, B.L. "Windows and People: A Literature Survey." U.S. Department of Commerce, National Bureau of Standards, June 1975.

Easson, I. "Fluorescent Lighting: A Selected Bibliography." Canadian Centre for Occupational Health and Safety, Hamilton, Ontario, December 1981.

Flynn, J., Hendrick, C., Spencer, T. and Martyniuk, O. "A Guide to Methodology Procedures for Measuring Subjective Impressions in Lighting." Journal of Illuminating Engineering Society, January 1979, 95-110.

Flynn, J., Spencer, T., Martyniuk, O. and Hendrick, C. "Interim Study of Procedures for Investigating the Effect of Light on Impression and Behaviour." Journal of Illuminating Engineering Society, October 1973, 87-94.

General Electric, Lamp Business Division. Incandescent Lamp Characteristics and Indicator Identifier.

Hawes, A. "Recent Progress and Future Development on Britisn Railways Suburban Stock." Passenger Environment, The Institute of Mechanical Engineers, London, 1972.

Henderson, S.T. and Marsden, A.M. "Lamps and Lighting." In I. Easson (Ed.), Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Hendrick, C., Martyniuk, O., Spencer, T. and Flynn, J. "Procedures for Investigating the Effect of Light on Impression." Environment and Behaviour, December 1977, 9(4), 491-510.

Kaufman, J.E. (Ed.), IES Lighting Handbook. (5th Edition) New York: Illuminating Engineering Society, 1972.

Krtilova, A. and Matousek, J. "Integrated Lighting." In I. Easson (Ed.), Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Lemons, T.M. and Robinson, A.V. "Does Visual Clarity Have Meaning for IES Illumination Recommendations for Task Lighting?" In I. Easson (Ed.), Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Lion, J.S., Richardson, E. and Browne, R.C. "A Study of the Performance of Industrial Inspectors Under Two Kinds of Lighting." In I. Easson (Ed.), Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Malone, R. "CTA Cars: No Frills, No Nonsense." Railway Age, May 10, 1982, 22-23.

Mayron, L.W. "Hyperactivity from Fluorescent Lighting - Fact or Fancy: A Commentary on the Report by O'Leary, Rosenbaum and Hughes." In I. Easson (Ed.), Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Murtha, D.M. and Heinig, P.E. "The Impact of the Built Environment on the Health and Lives of People: Selections from the Medline Database. A Survey of the Topics Covered and a Guide for Information Access." The Association for the Study of Man-Environment Relations.

Oborne, D.J. "Passenger Comfort: An Overview." Applied Ergonomics, 1978, 9(3), 131-136.

Popescu, M.P. and Grazdinaz, C. "The Eye Under Working Conditions with Fluorescent Lighting." In I. Esson (Ed.), *Fluorescent Lighting: A Selected Bibliography.* Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Prince, J.S. "More Lighting is Not Necessarily Better." In I. Easson (Ed.), *Fluorescent Lighting: A Selected Bibliography.* Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Ragsdale, K.H. "Lighting for Safety." In I. Easson (Ed.), *Fluorescent Lighting: A Selected Bibliography.* Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Rosenfeld, A. "Lighting." Department of Public Works, Toronto, (no date).

Singleton, W.T. *Introduction to Ergonomics.* Geneva: World Health Organization, 1972.

Streichardt, H. "Refreshments on Rails - Anachronism or Future Task of the Railway?" Rail International, Brussels, November 1981, 12(11), 457-459.

Sundberg, C.W. and Ferar, M. "Design of Rapid Transit Equipment for the San Francisco Bay Rapid Transit System." Human Factors, 1966, 8, 339-346.

Taylor, G.H. "Office Lighting and Its Effect on Good Employee Performance." In I. Easson (Ed.), *Fluorescent Lighting: A Selected Bibliography.* Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Thomas, R.J. "Negative Flashes: Some Information from Lamp Flicker Experiments." In I. Easson (Ed.), *Fluorescent Lighting: A Selected Bibliography.* Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Villani, S and Cipolla, B. "Ergo-ophthalmology and Ergo-optometry." In I. Easson (Ed.), *Fluorescent Lighting: A Selected Bibliography.* Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

Wilcock, H. "Recent Progress and Future Development in British Railways Mainline Stock." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Wotton, E. "Long Distance Railway Car Lighting." Report prepared for Behavioural Team, Toronto, June 30, 1983.

Young, J.A. "Passenger Comfort in Urban Transit Vehicles." Ontario Ministry of Transportation and Communications, January 1976.

No Author "Artificial Light at Work." In I. Easson (Ed.), *Fluorescent Lighting: A Selected Bibliography.* Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

No Author "Could Fluorescent Lighting be Harmful to Your Health?" In I. Easson (Ed.), *Fluorescent Lighting: A Selected Bibliography.* Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

No Author "Criteria for the Lighting of Printing Plans: Special Light for the Working Areas." In I. Easson (Ed.) Fluorescent Lighting: A Selected Bibliography. Hamilton, Ontario: Canadian Centre for Occupational Health and Safety, 1981.

1.7 SIGNS

Barkow, B. "The Human Factors of Words." Talk presented to Computer Systems Research Group, University of Toronto, March 12, 1981.

Barkow, B., Piipponen, V., Wallis, D., Hay, T., Scalzitti, B. and Hershfield, L. "Telidon Field Trial Evaluation: Technical Issues. Volume I and II." Report prepared for the Department of Communications, March 31, 1983.

Beadle, R.E. "Dot-Matrix Displays Herald Flexible Information Systems." Railway Gazette International, November 1982, 138(11), 917-918.

Cui, Jun-ming and Shen, Feng-ming "Some Experiments of Railway Light Signal Display." Acta Psychologica Sinica, 1979, 11(2), 207-220.

Cousins, J.S. "Industrial Design: Railway Vehicles." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Geiselman, R.E., Landee, B.M. and Christen, F.G. "Perceptual Discriminability As a Basis for Selecting Graphic Symbols." Human Factors, 1982, 24(3), 329-337.

Johnson, D.A. "Emergency Safety Instructions: Who Attends and Why?" In D. J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 1. New York: Academic Press, 1980.

Learet, F. "La Conduite sur l'Autoroute Effet de Signaux Lumineux sur le Niveau de Yilance du Conducteur." Ergonomics, 1973, 16(3), 309.

Mackett-Stout, J. and Dewar, R. "Evaluation of Symbolic Public Information Signs." Human Factors, 1981, 23(2), 139-151.

Mashour, M. "On Designing Signals and Their Meanings." Ergonomics, November 1977, 20(6), 659-670.

Michaelis, P.R. "An Ergonomist's Introduction to Synthesized Speech." In D.J. Oborne and J.A. Levis (Eds.), Human Factors on Transport Research, Volume 1. New York: Academic Press, 1980.

Priest, J. "Synthesized Speech: Ergonomic Implications for the Transportation Industry." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 1. New York: Academic Press, 1980.

Rilev, M.W., Cochran, D.J. and Ballard, J.L. "An Investigation of Preferred Shapes for Warning Labels." Human Factors, 1982, 24(6), 737-742.

Zwaga, H.J. and Boersema, T. "Evaluation of a Set of Graphic Symbols." State University of Utrecht, Netherlands, July 1981, (28), 1-22. (Abstract from Public Transport)

Zwaga, H.J., Boersema, T. and Rookmaaker, D.P. "Feasibility of Pictograms Used by the Dutch Railways." Ergonomics, 1973, 16(3), 306.

No Author "Symbol Signs: The Development of Passenger/Pedestrian Oriented Symbols for Use in Transportation - Related Facilities. Final Report." American Institute of Graphic Arts, New York, Contract No. DOT- OS-40192.

1.8 OTHER VISUAL STIMULI

Alcan Dofasco MLW Industries. LRC. (no date.)

Allen, G.F. Luxury Trains of the World. New York: Everest House, 1979.

Acking, C. "Translation of a Preliminary Research Report Concerning Visual Perception of Environment." The Lund Institute of Technology, December 20, 1967.

Bachman, J.A., Marchetti, J.W., Meacham, H.C., Uher, R.A. and Watson, R.B. "Improved Passenger Equipment Evaluation Program: Train System Review Report." Volume 8. LRC Federal Railroad Administration, Washington D.C., Report No. FRA/ORD-80/14, VIII, March 1979.

Barkow, B. and Clark, G.A. "Human Factors in Vehicle Design." In R.M. Soberman and H.A. Hazard (Eds.), Canadian Transit Handbook. Toronto, Ontario: University of Toronto - York University, January 1980.

Behavioural Team "Rail Travel: Pleasures and Pitfalls (An analysis of 20 Focus Groups Across the U.S.)." Prepared for Charles River Associates and Amtrak, September 1979.

Chaine, H., Gimbert, R., Vergely, J. and Neerman, P. "Respecting the Passenger Pays Off in Lyon." Railway Gazette International, March 1982, 138(3), 207-210.

Dorin, P. Coach Trains and Travel. Seattle, Washington: Superior Publishing Co., 1976.

Wichansky, A.M. "The Effects of the Ride Environment on Intercity Train Passenger Activities." Washington: Transportation Research Board Meeting, 1979.

Wilock, H. "Recent Progress and Future Development in British Railways Main-Line Stock." Passenger Environment. The Institute of Mechanical Engineers, London 1972.

1.9 SPACE

Diffrient, N., Tilley, A., Bardagjy, J. and Harman, D. Humanscale 1 - 9. Cambridge Mass.: The MIT Press, 1979.

Fruin, J.J. "Practical Passenger Capacity Evaluation Hawker Siddeley Bi-Level Cars." Unpublished Paper, January 1976.

Panero, J. and Zelnik, M. Human Dimension and Interior Space: A Source Book of Design Reference Standards. New York: Whitney Library of Design, 1979.

1.9.1 Public Spaces

Alcan Dofasco MLW Industries. LRC. (no date.)

Allen, G.F. Luxury Trains of the World. New York: Everest House, 1979.

Bachman, J.A., Marchetti, J.W., Meacham, H.C., Uher, R.A. and Watson, R.B. "Improved Passenger Equipment Evaluation Program: Train System Review Report." Volume 8. LRC Federal Railroad Administration, Washington, D.C., Report No. FRA/ORD-80/14, VIII, March 1979.

Beath, W.R., Beaumont, C. and Thomas, H.A. "Interior Furnishing of Rolling Stock." Passenger Environment. London: Institution of Mechanical Engineers, 1972.

Brezina, E., Barkow, B. and Bell, F. "Demonstration Track Testing - Three Contrasting Interior Designs." Internal Memorandum, Behavioural Team, June 1973.

Burnicle, D.S. and Heath, M. "Bus Interiors - with particular reference to the Leyland Titan." In F. Height and R. Cresswell (Eds.), Design for Passenger Transport. New York: Pergamon Press Inc., 1979.

Cousins, J.S. "Industrial Design: Railway Vehicles." Passenger Environment. London: Institution of Mechanical Engineers, 1972.

Diffrient, N., Tilley, A.R., Bardagjy, J.C. and Harman, D. Humanscale 1 - 9. Cambridge, Mass.: The MIT Press, 1979.

Dimitrov, M. "Standards of Hygiene for the Construction of New Rolling Stock for Passenger Coaches, Sleeping Cars and Restaurant Cars." Zeitschrift der OSShD, Warsaw, 1981, 24(6), 9-11.

Dorin, P. Coach Trains and Travel. Seattle, Washington: Superior Publishing Co., 1976.

Ford, R. "Automatic Door Mechanism for MK3S." Modern Railways, April 1983, 40(415), 182-183.

Fruin, J.J. "Practical Passenger Capacity Evaluation Hawker Siddeley Bi-Level Cars." Unpublished Paper, January 1976.

Hall, E.T. The Hidden Dimension. Garden City, New York: Anchor Books, 1969.

Height, F. and Cresswell, R. (Eds.), Design for Passenger Transport. London: Pergamon Press, 1979.

Hellewell, D.S. "Operational Requirements of Light Rail Vehicles." Proceedings of the Institution of Mechanical Engineers, 1983, 197B, 55-59.

Mehrabian, A. Public Places and Private Spaces. New York: Basic Books Inc., 1976.

Molony, G. "The Interior Design of Wide Bodied Aircraft." In F. Height and R. Cresswell (Eds.), Design for Passenger Transport. New York: Pergamon Press Inc., 1979.

Ontario Ministry of Transportation and Communications "Seating and Capacity Go Urban." Operational Planning Office, Environmental and Operational Planning Branch, February 1974.

Paek, S.L. "An Analysis of Sensory Hands as Identified by Selected Consumers." Textile Research Journal, December 1979, 49, 698-704.

Shipley, P. and West, A.E. "A User Opinion Study of the Quality of Railway Carriage Environments." Ergonomics, May 1973, 16(3), 306.

Small, B.M. "Environmental Health Factors in Falling Accidents." Report prepared for The Medical Engineering Section, Division of Electrical Engineering, National Research Council of Canada, November 1982.

Sommer, R. Personal Space, The Behavioural Basis of Design. Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1969.

Taylor, H.M. "Textiles for Indoor Thermal Comfort. Part 2 - Bedding, Carpets and Curtains." Textiles, 1983, 12(1), 13-16.

Vaughn, E.A. and Kim, C.J. "Definition and Assessment of Fabric Hand." Paper Presented at the 1975 National Technical Conference of the American Association of Textile Chemists and Colorists, Chicago, Illinois, October 15-17, 1975.

VIA Rail Canada Inc. "VIA Rail's 5 Year Program for Passengers with Special Needs 1981-1985." 1980.

Wener, R.E. and Kaminoff, R.D. "Environmental Clarity and Perceived Crowding." In A.D. Seidel and S. Danford (Eds.), Environmental Design: Research, Theory, and Application. Proceedings of the Tenth Annual Conference of the Environmental Design Research Association, Washington, D.C., 1979.

West, A., Ramagge, F., West, J. and Jones, H. "The Quality of Railway Carriage Environments." Applied Ergonomics, December 1973, 4(4), 194-198.

Wilcock, H. "Recent Progress and Future Development on British Railways Mainline Stock." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

1.9.2 Accommodation Spaces

Alcan Dofasco MLW Industries. LRC. (no date.)

Allen, G.F. Luxury Trains of the World. New York: Everest House, 1979.

Allen, G.F. "Inter-City Outlook on British Rail." Modern Railways, June 1978, 35(357), 253-256.

Barkow, B. and Clark, G.A. "Human Factors in Vehicle Design." In R.M. Soberman and H.A. Hazard (Eds.), Canadian Transit Handbook. Toronto, Ontario: University of Toronto - York University, January 1980.

Beath, W.R., Beaumont, C. and Thomas, H.A. "Interior Furnishing of Rolling Stock." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Branton, P. "Ergonomic Research Contributions to Design of the Passenger Environment." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Brezina, E., Barkow, B. and Bell, F. "Demonstration Track Testing - Three Contrasting Interior Designs." Internal Memorandum, Behavioural Team, June 1973.

Chaine, H., Gimbert, R., Vergely, J. and Neerman, P. "Respecting the Passenger Pays Off in Lyon." Railway Gazette International, March 1982, 138(3), 207-210.

Dimitrov, M. "Standards of Hygiene for the Construction of New Rolling Stock for Passenger Coaches, Sleeping Cars and Restaurant Cars." Zeitschrift der OSShD, Warsaw, 1981, 24(6), 9-11.

Dorin, P. Coach Trains and Travel. Seattle, Washington: Superior Publishing Co., 1976.

Drury, C.G. and Coury, B.G. "A Methodology for Chair Evaluation." Applied Ergonomics, 1982, 13(3), 195-202.

Dupont Canada, Inc. A Guide to Contract Carpeting. (no date)

Fruin, J.J. "Practical Passenger Capacity Evaluation Hawker Siddeley Bi-level Cars." Unpublished Paper, January 1976.

Gillies, T.K. "Rail Passenger Seat Development. Summary Report." Transport Canada Research and Development Centre (TDC), Montreal, Quebec, Report No. TP 2490, March 1980.

Hassenboehler, C.B.,Jr. and Wyatt, N. "Lint-Loss and Appearance-Change Tests for Blankets." Textile Research Journal, October 1979, 583-586.

Hawes, A. "Recent Progress and Future Development on British Railways Suburban Stock." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

Hellewell, D.S. "Operational Requirements of Light Rail Vehicles." Proceedings of the Institution of Mechanical Engineers, 1983, 197B, 55-59.

Heron, R., Smith, B., Alfieri, F. and Suen, L. "Canadian Overview of Technological and Systems Research and Development on Transportation for the Disabled." Paper Presented at the 62nd Annual Meeting of the Transportation Research Board, Washington, D.C., January, 1983.

Hiba, J.C. "Some Ergonomic Aspects in the Design of a Headrest for a Passenger Seat for Coaches." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research. Vol. 2. London, England: Academic Press, 1980.

Holt, D.J. "SPE S-9 Cabin Safety Provisions Committee Develops Standards for Aircraft Cabin Interiors and Furnishings." Aerospace Engineering, March 1983.

Ingham, P.E. and Edwards, R.J. "Comparison of Automotive Upholstery Fabrics." Wool Research Organization of New Zealand, Report No. 104, Christchurch, N.Z., October 1982, 1-26.

Innes, L.G. "Habitability Programme for the Royal Canadian Navy FHE 400 Hydrofoil Ship, First Progress Report, Bunk Design Development." Institute of Aviation Medicine, Report 64-RD-4.

Kolker, L. "Satisfying the Consumer's Demand For Meaningful Color." Textile Industries, March 1980, 38-41.

McGrath/Smart Associates, "Rail Passenger Seat Development: Passenger Evaluation." Transport Canada Research and Development Centre, December 1978, TP1815.

Munther, J. "Saloon or Compartment Coaches in Passenger Transport." ETR-Eisenbahntechnische Rundschau, May 1982, 31(5), 329-330, 333-334 and 336.

Noy, I.Y. and Crabtree, B. "Rail Passenger Seat Development: Human Engineering Contributions." Defence and Civil Institute of Environmental Medicine, Downsview, Ontario, November 1978, TP 1789.

Perren, B. "MK3 Sleepers to Rejuvenate Long-Haul Overnight Services." Modern Railways, August 1979, 36(371), 335-338.

Richards, V. "Growth, Economy, Function, Beauty: Marketplace Answer to Consumer Needs Offers All." Modern Textiles, April 1981, 22-27.

Richards, L.G., Kuhlthan, A.R. and Jacobson, I.D. "Passenger Ride Quality Determined from Commercial Airline Flights." 1975 Ride Quality Symposium. Williamsburg, Virginia, August 11-12, 1975. NASA TM X-3295, DOT-TSC-OST-75-40.

Scully, B. "Humanscale." Technical Information Service, National Research Council. Reprinted from Furniture Design and Manufacturing, June 1976.

Secord, T. and Rowan, W.G. "Rail Passenger Seat Development." Transport Canada Research and Development Centre. Report No. TP 2118, March 1980.

Seidel, L.E. "Industrial Upholstery." Textile Industries, December 1981, 72-73.

Solomon, K.M., Solomon, R.J. and Silien, J.S. "Passenger Psychological Dynamics." U.S. Department of Transportation. Contract H-804, June 1968.

Sundberg, C.W. and Ferar, M. "Design of Rapid Transit Equipment for the San Francisco Rapid Transit System." Human Factors, 1966, 8, 339-346.

Taylor, H.M. "Curtains." Textiles, 1980, 9(2), 38-42.

Waterhouse, R. "Aircraft, Trains, Buses and People." In F. Height and R. Cresswell (Eds.), Design for Passenger Transport. Oxford: Pergamon Press, 1979.

White, J.H.Jr. "The American Railroad Passenger Car." Museum of History and Technology, Smithsonian Institution, Washington, D.C.

Wilcock, H. "Recent Progress and Future Developments on British Railways Mainline Stock." Passenger Environment, The Institute of Mechanical Engineers, London, 1972.

Wineman, J.D. "Color in Environmental Design: Its Impact on Human Behavior." In A.D. Seidel and S. Danford (Eds.), Environmental Design: Research, Theory and Application. Proceedings of the 10th Annual Conference of the Environmental Design Research Assoc., Washington, D.C., 1979.

Young, J.A. "Passenger Comfort in Urban Transit Vehicles: A State of the Art Report." Ontario Ministry of Transportation and Communications, January 1976.

No Author "Railway Passenger Comfort." The Railway Gazette, September 18, 1964, 767-770.

No Author "Seating and Capacity." Ontario Ministry of Transportation and Communications, Planning Division. February 1974.

2. Behavioural Variables

Viton, P.A. "New Horizons in Travel Behavior Research." American Academy of Political and Social Science, November 1982, 464, 242.

Wandersman, A., Murday, D. and Wadsworth, J.C. "The Environment-Behavior-Person Relationship: Implications for Research." In A.D. Seidel and S. Danford (Eds.), Environmental Design: Research, Theory and Application. Proceedings of the 10th Annual Conference of the Environmental Design Research Assoc., Washington, D.C., 1979.

2.1 BOARDING AND LEAVING THE TRAIN

Barkow, B. and Clark, G.A. "Human Factors in Vehicle Design." In R.M. Soberman and H.A. Hazard (Eds.), Canadian Transit Handbook. Toronto, Ontario: University of Toronto - York University, January 1980.

Fritz, M. "Effect of Crowding on Light Rail Passenger Boarding and Alighting Times." M.S. Thesis, Transportation Centre, Northwestern University, Evanston, Illinois, 1981.

Height, F. and Cresswell R. (Eds.), Design for Passenger Transport. London: Pergamon Press, 1979.

Meyers, A.W., Stunkard, A.J., Coll, M. and Cooke, C.J. "Stairs, Escalators, and Obesity." Behavior Modification, July 1980, 4(3), 355-359.

Waterhouse, R. "Aircraft, Trains, Buses and People." In F. Height and R. Cresswell (Eds.), Design for Passenger Transport. Oxford: Pergamon Press, 1979.

No Author "Passenger Problems on Moving Buses." Department of the Environment and Department of Transport, Transport and Road Research Laboratory. Supplementary Report 520, Transport Engineering Division, Transport Systems Department, Crowthorne, Berkshire, 1980.

2.2 LOCATING YOUR "TERRITORY" ON THE TRAIN

Bowers, J.K. "Privacy, Territoriality, Personal Space, and Personality." In A.D. Seidel and S. Danford (Eds.), Environmental Design: Research, Theory and Application. Proceedings of the 10th Annual Conference of the Environmental Design Research Assoc., Washington, D.C., 1979.

Collet, P. and Marsh, P. "Seat Choice in an Airport Lounge." Man-Environment Systems, March 1980, 10(2), 83-106.

Goffman, E. The Presentation of Self in Everyday Life. Garden City, New York: Doubleday Anchor Books, 1959.

Insel, P.M. and Lindgren, H.C. Too Close for Comfort: The Psychology of Crowding. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1978.

Sharp, C. and Barkow, B. "Design and Facility Standards for Air Terminal Building Facilities." Report for Transport Canada, Airport Facilities Branch Administration, July 20, 1982.

Sossin, K.M. "Book Review - Human Territoriality: Survey of Behavioral Territories in Man with Preliminary Analysis and Discussion of Meaning. By Torsten Malmberg." Man-Environment Systems, 1982, 12, 47-48.

2.3 HANDLING LUGGAGE

Davis, G. (Luggage studies for Transport Canada)

Height, F. and Cresswell, R. (Eds.), Design for Passenger Transport. London: Pergamon Press, 1979.

Huellemann, K.D. "Kinesitherapy in Rehabilitation of Coronary Patients: Indicated, Dosed and Supervised." Therapiewoche (Germany, West), 1980, 30(32), 5211-5217.

Waterhouse, R. "Aircraft, Trains, Buses and People." In F. Height and R. Cresswell (Eds.), Design for Passenger Comfort. London: Pergamon Press, 1979.

Williams, J.D. "Passenger-Accompanied Luggage." Applied Ergonomics, September 1977, 8(3), 151-157.

2.4 ACTIVITIES IN THE ACCOMMODATION SPACE

Codol, J.P. "Comfortable Traveling - Spatial Factors Concerning Passenger Comfort in Bus." Revue de Psychologie Appliquee, 1977, 27(2), 69-88.

Grandjean, E. "Ergonomics of Nonvocational Activities." Ergonomics, 1979, 22(6), 621-630.

Koneya, M. "Privacy Regulation: A Challenge for Environmental Planners and Designers." College of Architecture, University of Nebraska, Lincoln, Nebraska.

Wichansky, A.M. "The Effects of the Ride Environment on Intercity Train Passenger Activities." Washington: Transportation Research Board Meeting, 1979.

2.4.1 Sitting

Cousins, J.S. "Industrial Design: Railway Vehicles." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

McGrath/Smart Associates. "Rail Passenger Seat Development: Passenger Evaluation." Transport Canada, December 1978.

Munther, J. "Saloon or Compartment Coaches in Passenger Transport." ETR-Eisenbahn-technische Rundschan, May 1982, 31(5), 329-330.

1975 Ride Quality Symposium, Williamsburg, Virginia, August 11-12, 1975, NASA Technical Memo X-3295, November 1975.

2.4.2 Reclining

Diffrient, N., Tilley, A. and Bardagjy, J. Humanscale 1/2/3. Cambridge, Mass.: The MIT Press, 1979.

Panero, J. and Zelnik, M. Human Dimensions and Interior Space: A Sourcebook of Design Reference Standards. London: Architectural Press Ltd., 1979.

2.4.3 Reading

Bronzaft, A.L. and McCarthy, D.P. "The Effect of Elevated Train Noise on Reading Ability." Environment and Behaviour, 1975, 7(4), 517.

Jacobson, I.D. and Martinex, J. "The Comfort and Satisfaction of Air Travellers - Basis for a Descriptive Model." Human Factors, 1974, 46-55.

Richards, L.G. and Jacobson, I.D. "Ride Quality Evaluation I. Questionnaire Studies of Airline Passenger Comfort." Ergonomics, 1975, 18, 129-150.

Wichansky, A.M. "Effects of the Ride Environment on Passenger Activities: A Field Study on Intercity Trains." Washington: U.S. Department of Transportation, January 1979.

Wichansky, A.M. "The Effects of Ride Environment on Intercity Train Passenger Activities." Washington: Transportation Research Board Meeting, 1979, 74-80.

2.4.4 Talking and Social Interactions

Goffman, E. The Presentation of Self in Everyday Life. Garden City, New York: Doubleday Anchor Books, 1959.

Insel, P.M. and Lindgren, H.C. Too Close for Comfort: The Psychology of Crowding. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1978.

Koneya, M. "Privacy Regulation: A Challenge for Environmental Planners and Designers." College of Archeticture, University of Nebraska, Lincoln, Nebraska.

Mitchelson, R.L. "The Effect of Social Heterogeneity within Urban Travel Corridors on the Travel Behavior of Residents." Professional Geographer, 1982, 34(2), 185-196.

Richards, L.G. and Jacobson, I.D. "Ride Quality Evaluation I. Questionnaire Studies of Airline Passenger Comfort." Ergonomics, 1975, 18, 129-150.

Rudrapatna, A. "A Trade-Off Analysis Design Tool - Aircraft Interior Noise-Motion / Passenger Satisfaction Model." Unpublished Doctoral Dissertation. University of Virginia (Charlottesville), 1977.

Wichansky, A.M. "Effects of the Ride Environment on Passenger Activities: A Field Study on Intercity Trains. Washington: U.S. Department of Transportation, January 1979.

Wichansky, A.M. "The Effects of the Ride Environment on Intercity Train Passenger Activities." Transportation Research Board Meeting, 1979, 74-80.

2.4.5 Playing Games

Wichansky, A.M. "Effects of the Ride Environment on Passenger Activities: A Field Study On Intercity Trains." Washington: U.S. Department of Transportation, January 1979.

No Author "Video Games Really Take Off." Globe and Mail, August 4, 1983.

2.4.6 Sightseeing

Behavioural Team "Rail Travel: Pleasures and Pitfalls (An analysis of 20 Focus Groups across the U.S.)." Prepared for Charles River Associates and Amtrak, September 1979.

2.4.7 Working

Jacobson, I.D. and Martinez, J. "The Comfort and Satisfaction of Air Travellers - Basis for a Descriptive Model." Human Factors, 1974, 16, 46-55.

Tachet, P. and Riondy, J. "Special Coaches." Revue Generale des Chemins de Fer, December 1981, 100, 751-762.

Wichansky, A.M. "Effects of the Ride Environment on Passenger Activities: A Field Study on Intercity Trains." Washington: U.S. Department of Transportation, January 1979.

Wichansky, A.M. "The Effects of Ride Environment on Intercity Train Passenger Activities." Washington: Transportation Research Board Meeting, 1979, 74-80.

No Author "The Business of Travel." Management Today, March 1983, 40 pp supplement.

No Author "Lyntog MK.3- Denmark's New Generation of Inter-City Train." Modern Railways, November 1982, 39(410), 506-509.

2.4.8 Self Care

Mehrabian, A. Public Places and Private Spaces. New York: Basic Books Inc., 1976.

2.4.9 Care of Travelling Companions

Breslow, M., Pomerantz, B. and Haberkorn, S. "Mobility of Senior Citizens Bibliography." Institute of Gerontology, University of Michigan, October 1974.

Feeney, R.J., Ashford, N.J., Morris, A. and Gazely, D. "Travel and the Handicapped: A Project Summary." Transport and Road Research Laboratory, Department of the Environment, Department of Transport England, Supplementary Report 480, 1979.

Heron, R.M. "An Ergonomic Evaluation of a Wheelchair Restraine Systems Designed for Rail Travel." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 1. New York: Academic Press, 1980.

Levison, W.H. "A Methodology for Quantifying the Effects of Aging on Perceptual-Motor Capability." Human Factors, 1981, 23(1), 87-96.

Richards, L.G., Hoel, L.A. and Foulke, E. "Improving Access to Public Transportation for Persons with Sensory Impairments." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 1. New York: Academic Press, 1980.

Romagnoli, R. "Access of Disabled Persons to FS Low-Entrance Coaches." La Tecnica Professionale, Rome, September 1981, 9, 492-495.

Stoudt, H.W. "The Anthropometry of the Elderly." Human Factors, 1981, 23(1), 29-37.

Wacks, M. Transportation for the Elderly. Berkeley, California: California University Press, 1979.

No Author "Does It Have To Be This Way?" Research in Gerontology. Research News, Division of Research Development and Administration, University of Michigan, November/December 1975, XXVI(5/6).

No Author "NSB's Coaches for the Disabled." Railway Gazette International, October 1978, 134(10), 754.

No Author "The Future Role of Rail." Final Report. Ontario Task Force on Provincial Rail Policy, January 1981.

No Author "Via Rail's 5 Year Program for Passengers with Special Needs, 1981-1985." Via Rail Inc., 1980.

2.4.10 Sleeping

Armstrong, J.H. "Amtrak's New Superliners: A Touch of Class in the West." Railway Age, December 1979, 180(23), 36-39.

Frazier, T.W., Benignus, V.A., Every, M.G. and Parker, J.F. "Effects of 72-Hour Partial Sleep Deprivation on Human Behavioural and Physiological Response Measures: Final Report." In Government Reports Announcements, Report No. AD-732 872, August 1971.

Goodenough, D.R., Sapen, J., Cohen, H., Portnoff, G. and Shapiro, A. "Some Experiments Concerning the Effects of Sleep on Memory." Psychophysiology, November 1971, 8(6), 749-762.

Hamilton, P., Wilkinson, R.T. and Edwards, R.S. "A Study of Four Days Partial Sleep Deprivation." In W.P. Colquhoun (Ed.), Aspects of Human Efficiency: Diurnal Rhythm and Loss of Sleep. London: English Universities Press, 1972, 101-112.

Hartmann, E.L. and Zwilling, G.R. "A Study of Long and Short Sleepers." U.S. Government Research and Development Reports. Report No. AD-711 579.

Hill, R.F. "Rolling Hotel Aims to Give a Quiet Night." Railway Gazette International, June 1981, 137(6), 498-499.

Hill, R.F. and Garratt, C.H. "The Mark III Sleeping Cars." Institution of Mechanical Engineers, Procs. 1982, 196(12), 87-94.

Kramer, M., Roth, T., Trindar, J. and Cohen, A. "Noise Disturbance and Sleep: The Relationship of Noise Disturbed Sleep to Post-Sleep Behaviour: An Exploratory Study." U.S. Government Research and Development Reports. Report No. AD-729 431, January 1971.

Morgan, P.A. "Effects of Noise Upon Sleep." TRC Report No. BR-23810, December 1970.

Perren, B. "MK-3 Series Sleeper Enter Service." Modern Railways, Shepperton, February 1982, 39(401), 65-68.

Perren, B. "MK-3 Sleepers to Rejuvenate Long-Haul Overnight Services." Modern Railways, August 1979, 36(371), 335-338.

Sommer, H.C. and Harris, C.S. "Combined Effects of Noise and Vibration on Mental Performance as a Function of Time of Day." Aerospace Medicine, May 1972, 43(5), 479-482.

Vernet, M. "Comparison Between Train Noise and Road Noise Annoyance During Sleep." Journal of Sound and Vibration, March 1983, 87(2).

Wichansky, A.M. "Effects of the Ride Environment on Passenger Activities: A Field Study on Intercity Trains." Washington: U.S. Department of Transportation, January 1979.

Wichansky, A.M. "The Effects of Ride Environment on Intercity Train Passenger Activities." Washington: Transportation Research Board Meeting, 1979, 74-80.

Wilkinson, R.T. "Reduced Sleep." Proceedings of Meeting of the Occupational Psychology Section of the British Psychological Society, 1968.

No Author "Sleeping Cars to Meet Today's Needs." Railway Gazette International, October 1974, 130(10), 400-403.

No Author "Talgo Offers a New Angle on Sleeping Car Design." Railway Gazette International, March 1974, 130(3), 2.

2.4.11 Intimate Social Behaviours

Greene, B.F., Bailey, J.S. and Barber, F. "An Analysis and Reduction of Disruptive Behaviour on School Buses." Journal of Applied Behaviour Analysis, 1981, 14(2), 177-192.

Koneya, M. Privacy Regulation: A Challenge for Environmental Planners and Designers. Lincoln, Nebraska, No date indicated.

Richardson, J. and Stroud, P.C. "Passenger Requirements in an Automated Transport System." Transport and Road Research Laboratory, Berkshire, England, 1975.

No Author "Sexual Harassment: How to Handle it on Business Trips." Glamour, September 1980, 78, 100.

2.4.12 Smoking

Seiff, H.E. "Carbon Monoxide as an Indicator of Cigarette-Caused Pollution Levels in Intercity Buses." National Transportation Safety Board, Bureau of Motor Carrier Safety, Washington, D.C., April 1973.

2.5 TRANSITIONS BETWEEN ACCOMMODATION SPACE AND PUBLIC SPACE

Howard, I.P. and Templeton, W.B. Human Spatial Orientation. New York: John Wiley and Sons, 1966.

Johnson, B.M. "Door-Use Study." National Research Council, Ottawa 1981.

Seaton, R.W. and Munson, P. "Use of Doorways and Multi-leaf Sets of Doors: An Exploratory Study." Prepared for the National Research Council, December 1980.

Seaton, R.W. "Manual Operation of Doors." Man-Environment Systems, 1981, 11, 207-214.

2.6 ACTIVITIES IN COMMON OR PUBLIC SPACES

Beath, W.R., Beaumont, C. and Thomas, H.A. "Interior Furnishing of Rolling Stock." Passenger Environment, The Institute of Mechanical Engineers, London 1972.

De Neufville, R. and Grillot, M. "Design of Pedestrian Space in Airport Terminals." Transportation Engineering Journal of the American Society of Civil Engineers, January 1982, 108(TE1).

Mehrabian, A. Public Places and Private Spaces. New York: Basic Books, 1976.

2.6.1 Aisles

Barkow, B. and Clark, G.A. "Human Factors in Vehicle Design." In R.M. Soberman and H.A. Hazard (Eds.), Canadian Transit Handbook. Toronto, Ontario: University of Toronto - York University, January 1980.

Suzuki, P.T. "Germans and Turks at Germany's Railroad Stations: Interethnic Tensions in the Pursuit of Walking and Loitering." Urban Life, January 1976, 4(4), 387-412.

2.6.2 Washrooms, Toilets

Henning, D. "The Use of Washroom Facilities in a Theatre Complex." National Research Council, Ottawa, February 1975.

McClelland, I.L. "The Ergonomics of Toilet Seats." Human Factors, 1982, 24(6) 713-725.

2.6.3 Lounges, Snack Bars and Restaurants

Alcan Dofasco MLW Industries, LRC. (no date)

Allen, G.F. "Inter-City Outlook on British Rail." Modern Railways, June 1978, 35(357), 253-256.

Behavioural Team "Rail Travel: Pleasures and Pitfalls (An analysis of 20 Focus Groups across the U.S.)." Prepared for Charles River Associates and Amtrak, September 1979.

Brink, H. and Klesper, O. "Quick-Pick Test Car." Glasers Annalen ZEV, February 1974, 98(2), 33.

Dublin, A.D. "Historical Perspective." Transportation Research Institute Conference Report, Proceedings of the Carnegie-Mellon Conference on Improved Passenger Tain Service December 2-4, 1975. Carnegie-Mellon University, Pittsburgh, Pennsylvania, 1976, 17-34.

Ekstrom, S. "Catering on Board." Schiff und Hafen, December 1976, 28.

Graham, H.L. "Passenger Amenities Including Terminals." Transportation Research Institute Conference Report, Proceedings of the Carnegie-Mellon Conference on Improved Passenger Train Service December 2-4, 1975. Carnegie-Mellon University, Pittsburgh, Pennsylvania, 1976, 157-165.

Grandjean, E. "Ergonomics of Non-Vocational Activities." Ergonomics, 1979, 22(6), 621-630.

King, F.E. "Review of Current Systems." Transportation Research Institute Conference Report, Proceedings of the Carnegie-Mellon Conference on Improved Passenger Train Service, December 2-4, 1975. Carnegie-Mellon University, Pittsburgh, Pennsylvania, 1976, 35-44.

Perren, B. "How Long Will the SNCF's TEEs Survive?" Modern Railways, January 1982, 39(400), 34-36.

Perren, B. "Train Catering: Achilles' Heel or Marketing Tool?" Modern Railways, October 1978, 35(361), 445-453.

Sackmann, W. "Drinking Water in Dining Cars." Der Eisenbahningenieur, Darmstadt, ISSN 0013-2810, 1982, 33(3), 103-110.

Streichardt, H. "Refreshments on Rails: Anachronism or Future Task of the Railways?" Rail International, Brussels, November 1981, 12(11), 457-459.

Tennyson, E.L. "Scheduling, Operations & Service." Transportation Research Institute Conference Report, Proceedings of the Carnegie-Mellon Conference on Improved Passenger Train Service December 2-4, 1975. Carnegie-Mellon University, Pittsburgh, Pennsylvania, 1976, 137-148.

No Author "Amtrak and Via Go For Comfort." International Railway Journal, August 1982, 39-39.

No Author "New British Rail Restaurant and Buffet Cars." Modern Railways, November 1973, 30(302), 439-441.

2.7 GENERAL PSYCHOLOGICAL CONSIDERATIONS

No Author "Crime and Vandalism in Public Transportation." National Research Council, Transportation Research Record 487, Washington, D.C., 1974.

2.7.1 Regulation Of Human Contact

Greenberg, C.I., Strube, M.J. and Myers, R.A. "A Multi Trait Multi Method Investigation of Interpersonal Distance." Journal of Nonverbal Behavior, 1980, 5(2), 104-114.

Mackintosh, E., West, S and Saegert, A. "Two Studies of Crowding in Urban Public Spaces." Environment and Behavior, June 1975, 7(2), 159-184.

Shellow, R., Romualdi, J.P. and Bartel, E.W. "Crime in Rapid Transit Systems: An Analysis and a Recommended Security and Surveillance System." In Crime and Vandalism In Public Transportation. Transportation Research Record 487, Washington, D.C.: Transportation Research Board, 1974.

Stillitz, I. "The Role of Static Pedestrian Groups in Crowded Spaces." Ergonomics, 1969, 12(6), 821-839.

Thrasher, E.J. and Schnell, J.B. "Studies of Public Attitudes Toward Transit Crime and Vandalism." In Crime and Vandalism In Public Transportation. Transportation Research Record 487, Washington, D.C.: Transportation Research Board, 1974.

Thrasher, E.J. and Schnell, J.B. "Summary Report on Vandalism and Passenger Security in the Transit Industry." In Crime and Vandalism in Public Transportation. Transportation Research Record 487, Washington, D.C.: Transportation Research Board, 1974.

No Author "Crime and Law Enforcement in Transportation Systems 1964 - March 1982." National Technical Information Service, Springfield VA, April 1982.

2.7.2 Relation Between Perceived Cost of Furnishings and "Comfort"

Hafter, G.H. "Passenger Comfort on London's Underground." Passenger Environment. The Institute of Mechanical Engineers, London 1972.

2.7.3 Relation Between Perceived Cleanliness and "Comfort"

2.7.4 Perceived and Actual Safety

Gregg, S.J. "Are Roads Safer Than Railways?" Modern Railways, April 1983, 40(415), 200-201.

Hambeck, W. and Pueschel, K. "Death by Railway Accident Incidence of Traumatic Asphyxia." Journal of Trauma, 1981, 21(1), 28-31.

Haynes, R.S. "Evaluation of a Behavioral Approach for Improving Operator Training, Performance, and Passenger Safety in the Mass Transit Industry." Abstracts International, February 1982, 42(8-B).

Hill, C.E. and Borenstein, M.A. "Airline Passenger Safety - 2 Studies in FAA Dalliance." Inst. Publ. Interest Representation, Washington, D.C., 1978, 14(8), 36.

Holt, D.J. "SAE S-9 Cabin Safety Provisions Committee Develops Standards for Aircraft Cabin Interiors and Furnishings." Aerospace Engineering, March 1983, 31-33.

Houston, A.M. "Fire Resistance and Toxicity of Plastics in Transportation Vehicles." Technical Information Service, National Research Council, August 1976.

Johnson, D.A. "Emergency Safety Instructions: Who Attends and Why?" In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 1. New York: Academic Press, 1980.

Lehe, P. and Jahn, A. "Fire Indicator Device for Passenger Coaches." DET-Die Eisenbahntechnik, March 1982, 30(3), 113-117.

Lukasiewicz, J. An Assessment of Canadian Railways Safety. January 1980.

Raphael, B. "A Primary Prevention Action Programme: Psychiatric Involvement Following a Major Rail Disaster." Journal of Death and Dying, 1979-80, 10(3), 211-226.

Richards, L.G., Jacobson, I.E. and Hoel, L.A. "Passenger Securitiy In Public Transportation: Psychological and Environmental Factors." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 1. New York: Academic Press, 1980.

Rolt, L.T.C. Red For Danger. A History of Railway Accidents and Railway Safety. London: David and Charles, 1982.

No Author "Aberdeen Gets MKIII Sleepers." Railway Gazette International, January 1982.

No Author R44, Daily News, December 29, 1975.

2.7.5 Phobias, Fears

Grossbart, S. and Amedeo, D. "The Process of Experiencing Feelings in Environments: Exploratory Modeling." In A.D. Seidel and S. Danford (Eds.), Environmental Design: Research, Theory and Application. Proceedings of the 10th Annual Conference of the Environmental Design Research Assoc., Washington, D.C., 1979.

Tainsh, M.A. "The Symptoms Reported by Long Distance Travellers." Applied Ergonomics, December 1975, 6(4), 209-212.

2.7.6 Stress Reduction

Lundberg, U. "Urban Commuting: Crowdedness and Catecholamine Excretion." Department of Psychology, University of Stockholm, October 1975, No. 453.

Schoultz, Michael B. and Snyder, William J. "Passenger Perceptions of the Helicopter: Ride-Quality Considerations." Transportation Research Record 646, Transportation Ride Quality. Washington, D.C.: National Academy of Science, 1977.

Singer, J.E., Lundberg, U. and Frankenhaeuser, M. "Study on the Train: A Study of Urban Commuting." Psychological Laboratories, University of Stockholm, December 1974, No.425.

Smith, R.P "Boredom: A Review." Human Factors, June 1981, 23, 329-340.

Tainsh, M.A. "The Symptoms Reported by Long Distance Travellers." Applied Ergonomics, December 1975, 6(4), 209-212.

2.7.7 Entertainment, Festivities

Tachet, P. and Riondy, J. "Special Coaches." Revue Generale des Chemins de Fer, December 1981, 100, 751-762.

2.7.8 Special Travel Groups

Tachet, P. and Riondy, J. "Special Coaches." Revue Generale des Chemins de Fer, December 1981, 100, 751-762.

2.7.9 Travelling with Pets, Valuable Livestock, etc.

3. Interactions With Rail Personnel

3.1 IDENTIFYING HELP, INFORMATION, OR AUTHORITY FIGURES

Jullien, M. "Police and Customs Formalities in International Trains." Revue Generale des Chemins de Fer, June 1982, 101, 353-358.

No Author "Presenting a Special Image." Food Service and Hospitality, January 1983, 5(11), 22-23.

3.2 TRAINING AND DEMEANOR OF STAFF

Andersen, J.E. "Three-Shift Working - A Sociomedical Study." Publikation 42, Socialforskningsinstituttet, 1970, 2 Volumes, 336 and 277.

Bibily, B. "Grete, Mabel and Murabel at Your Service." Railway Gazette International, November 1982, 903-905.

Bravo, J.E. "Sleep and Shift Work (Relationship to Pathology Observed)." Revista Seguridad, April-June 1974, No. 53, 38-43.

Brown, I.D. "Error-Correction Probability as a Determinant of Drivers' Subjective Risk." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Carugati, F., Cipolloni, V., Melli, C and Ricci Bitti, P. "The Effect of Alteration of the Circadian Rhythm on Some Psychi Functions in a Group of State Railways Workers." Bolletino de Psicologia Applicata, February 1971.

Cernobel'skij, A.B. "Safety in Transport Systems and Hours of Work." Bezopasnost' Truda v Promyslennosti, January 1974, (1), 36-37.

DeJong, J.R. "Some Outcomes of an Investigation into the Effects of the Application of Shiftwork Systems." International Journal of Production Research, January 1974, 12(1), 1-19.

Drucker, E.H., Cannon, L.D. and Ware, J.R. "The Effects of Sleep Deprivation on Performance over a 48-Hour Period." Ergonomics Information Analysis Center, Department of Engineering Production, University of Birmingham, England, May 1980.

Fitzgerald, J.G. "An Adjustable, Tiltable Seat from Sonar/Visual Display Operators." Royal Naval Physiological Laboratory, Ministry of Defence, Hamps, England, May 1977.

Foret, J. and Benoit, O. "Sleep Structure of Workers on Rotating Shifts." Electroencephalography and Clinical Neurophysiology, 1974, 37(4), 337-344.

Froberg, J.E. and Akerstedt, T. "Effects of Night Work and Shift Work on Health." Arbeitsmedizin-Sozialmedizin-Praventivmedizin, October 1974, 9(10), 223-226.

Goldman, E.I. and Kopirovskij, K.M. "Conditions and Arduousness of Work Presenting Significant Nervous and Emotional Stress." Gigiena Truda i Professional'nye Zabolevanija, March 1974, (3), 1-4.

Harris, C.S. "Aftereffects of Random and Fixed Intermittent Sound on Human Performance." Inhouse Research for the Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio, Report No. AMRL-TR-76-75, September 1976.

Johnson, L.C. and Spinweber, C.L. "Quality of Sleep and Performance in the Navy: A Longitudinal Study of Good and Poor Sleepers." Naval Health Research Center, San Diego, California, Report No. 82-8.

Mayerovai, M. "Work Motivation in Some Railway Transport Professions." Psychologie V Ekonomicke Praxi, 1966, (3-4), 45-56.

Michon, J.A. "The New Driver." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Modini, R.A., Molina, J.C. and Saforcada, E. "Alcoholism in a Group of Railway Workers." Acta Psiquiatrica y Psicologica de America Latina, March 1977, 23(1), 50-57.

Preston, B. "The Effectiveness of Children's Road Safety Education." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Reinberg, A. "Circadian Rhythm Study of Effects of Change in Working Hours." Archives des Maladies Professionnelles, March 1974, 35(3), 373-394.

Veling, I.H. "Cognitive Testing in Driver Licensing." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

Wilkinson, R.T. "Hours of Work and the Twenty-Four-Hour Cycle of Rest and Activity." In Psychology at Work. Harmondsworth, Middlesex: Penguin Books, 1971, 31-54.

Williams J. and Jones, D.M. "Noise and Driver Performance." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London, England: Academic Press, Inc., 1980.

No Author "Research for a Better Work Environment: A Summary of Reports on Four Central Research Areas." The Fund, Stockholm, Sweden, March 1975, 92.

3.3 EMERGENCY MANAGEMENT

Hohenemser, C., Kates, R. and Slovic, P. "The Nature of Technological Hazard." Science, April 22, 1983, 220.

Mart, R. and Phippe, P. "Electronics Keep the Clocks in Step." Railway Gazette International, November 1982, 91.

Rolt, L.T.C. Red for Danger. A History of Railway Accidents and Railway Safety. London: David and Charles, 1982.

Schwartz, J.J. and Ekkers, C.L. "Task and Load Difficulties in Directing and Regulating a Complex Technical System." Mens en Onderneming, March-April 1976, 30(2), 85-108.

Siddall, E. "Risk, Fear and Public Safety." Atomic Energy of Canada Ltd., April 1981.

4. General References

Adams, G. "Transportation Users: Demands and Needs." National Technical Information Service, Springfield, Virginia, February 1977. (Bibliography)

Adams, G. "Travel Habits and Patterns, Vol. 2, 1974-1977." National Technical Information Service, Springfield, Virginia, February 1977.

Adams, G. "Travel Habits and Patterns, Vol. 1, 1964-1973." National Technical Information Service, Springfield, Virginia, January 1976.

Andresen, O. "The Influx of Passengers on the DSB." Rail International, Bruxelles, February 1983, 14(2), 3-5.

Armstrong, J.H. "Amtrak's New Superliners: A Touch of Class in the West." Railway Age, October 10, 1979, 36-39.

Bachman, J.A., Marchetti, J.W., Meacham, M.C., Uher, R.A. and Watson, R.B. "Improved Passenger Equipment Evaluation Program: Train System Review Report." Volume 9 - SPV2000. Federal Railroad Administration, Washington DC, Report No. FRA/ORD-80/14, IX, March 1979.

Bachman, J.A., Marchetti, J.W., Meacham, H.C., Uher, R.A. and Watson, R.B. "Improved Passenger Equipment Evaluation Program: Train System Review Report." Volume 8. LRC Federal Railroad Administration, Washington DC, Report No. FRA/ORD-80/14, VIII, March 1979.

Beeasdale, C. "Inter-City: Towards Viability." Modern Railways, April 1983, 40(415), 212-213.

Boocock, D. and King, B.L. "The Development of the Prototype Advanced Passenger Train." Institution of Mechanical Engineers, Procs. 1982, 196(6), 35-46.

Botham, G.J.M. "The Design and Construction of 25 KV Electrical Multiple Unit Trains for the Kowloon-Canton Railway." (British Section). Hong Kong Engineer, November 1982, 10(11), 49-54.

Botstiber, W. "Passenger Comfort; Letter, Discussion." Aviation Week and Space Technology, January 20, 1969, 90, 94.

Botstiber, D.W. "Passenger Comfort; Letter." Aviation Week and Space Technology, November 18, 1968, 89, 142.

Bouley, J. "High Speed Trains Throughout The World." Institution of Mechanical Engineers, Procs. Part B, February 1983, 197, 43-48.

Branton, P. "Ergonomic Research Contributions to Design of the Passenger Environment." Passenger Environment. The Institute of Mechanical Engineers, London 1972.

Bugge, W.A. "BART in Operation - Innovations in Rapid Transit." Transportation Engineering Journal, May 1974, 100, 335-352.

Campbell, G. "Passenger Trains Find Their Role in Canada." Railway Gazette International, December 1981, 137(12), 1047-1049.

Chaine, H. et al. "Respecting the Passenger Pays Off in Lyon." Railway Gazette International, March 1982, 138(3), 207-210.

Charles River Associates Inc. "On the Development of a Theory of Traveler Attitude - Behavior Interrelationships." 3 Volumes. Final Report. Washington: U.S. Department of Transportation, August 1978.

Conner, D.W. "Passenger Comfort Technology for System Decision Making." National Aeronautics and Space Administration, Hampton, VA., Report No. NASA-TM-81875, August 1980.

Dayal, R. "All But Overwhelmed by Long-Distance Travellers." Railway Gazette International, October 1982, 138(10), 820-822.

Dimitrier, M. "Standards of Hygiene for the Construction of New Rolling Stock for Passenger Coaches, Sleeping Cars and Restaurant Cars." Zeitschrift der OSShD, Warsaw, 1981, 24(6), 9-11.

Dupuy, J. "380 km/h." Rail International, July/August 1981, 12(7-8), 296-302.

Elmaraghy, W.H., Gaiser, J.A. and Bexon, H.J. "The LRC Coach Trucks and Suspension." American Society of Mechanical Engineers, January 1979, Conference Paper.

Ford, R. "Inter-City After APT-P." Modern Railways, 1983, 40(412), 13-17.

Ford, R. "APT Inaugural Run - 7 December 1981." Modern Railways, February 1982, 62-63.

Garrett, V.K. "Innovative Design Features of Washington's Metrorail System." Transportation Research News, (103), Transportation Research Board, Washington, D.C. November/December 1982.

Gartner, E. and Komler, M. "Ergonomically Designed and Air Conditioned Driver's Cab of Electric Locomotive, Class BR212/243." DET-DiemEisenbahntechnik, February 1983, 31(2), 69-72.

Geveke, K. "How Innovative Marketing Brought the Passenger Back." Railway Gazette International, February 1983, 139(2), 101-103.

Glueck, H. "Aerodynamics of High Speed Trains. Review of the State of Knowledge." AET - Archiv fur Eisenbahntechnik, Darmstadt, 1981, 36, 23-28.

Hammond, I. "XPT Joins the High Speed Club." International Railway Journal, February 1982, 22(2), 14-15 and 17-18.

Harwell, A. "Amtrak - A Critical Appraisal From the Viewpoint of the Consumer." Transportation Research Forum, December 1972.

Hawes, A. "Recent Progress and Future Development on British Railways Suburban Stock." Passenger Environment. The Institute of Mechanical Engineers, London 1972.

Hay, W.W. Railway Engineering. New York: John Wiley, 1980.

Height, F. and Cresswell, R. (Eds.), Design for Passenger Transport. New York: Pergamon Press, Inc., Maxwell House, Fairview Park, Elmsford, 1979.

Hellewell, D.S. "Operational Requirements of Light Rail Vehicles." Institution of Mechanical Engineers, Procs. Part B, February 1983, 197, 55-59.

Hill, R.F. "Rolling Hotel Aims to Give a Quiet Night." Railway Gazette International, June 1981, 137(6), 498-499.

Hirten, J.E. "The Bias in Transit Planning." Modern Railroads, May 1975.

Hitchcock, C.F. "Today and Tomorrow - The Rights and Remedies of Airline Passengers." Trial, 1981, 17(8), 34.

Iiyama, Y. "Systems - Ergonomic Approaches to Design and Operation of Today's Railroads." Human Factors, February 1980, 22(1), 15-24.

Kasiske, H. "New Railway Vehicle Developments in the GDR." ZEV-Glasers Annalen, Berlin, 1981, 105(11), 339-346.

Kirby, R.H., Morgan, B.B. and Coates, G.D. "Analysis of Ride Quality Stimuli of Mass Transit Systems." Catalog of Selected Documents in Psychology, 1982, 12(3), 38.

Kirk, N.S. and Corlett, E.N. "Ergonomics of Passenger Comfort - Introduction." Applied Ergonomics, 1978, 9(3), 131.

Kizzia, T. "Moving People: The Search for Tomorrow." Railway Age, April 13, 1981.

Kogi, K. "Passenger Requirements and Ergonomics in Public Transport." Ergonomics, 1979, 22(6), 631-640.

Korotkij, A.P. "Development of Rail Traffic Over Recent Years in the U.S.S.R. Die Bundesbahn." Darmstadt, ISSN 0007-5876, April 1982, 58(4), 297-299.

Kuhlthau, A.R., Richards, L.G. and Jacobson, I.D. "Future Problems and Research Needs Related to Passenger Comfort." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London: Academic Press, Inc., 1980.

Kuller, R. "A Semantic Model for Describing Perceived Environment." National Swedish Building Research Summaries, Stockholm, Sweden, 1972.

Linder, D. "High Speed Ground Transport of Passengers." Transport and Road Research Laboratory, Department of the Environment, Department of Transport, Berkshire, England, 1979.

Luebke, D. "Research and Development in Tracked Transport." Railway Technical Review, 1982/83, 24, 39-42.

Lukasiewicz, J. "High-Speed Trains en Route to Profit." Globe and Mail, Toronto, Ontario, June 6, 1983.

Lukasiewicz, J. "Passenger Policy and Technology: Passenger Rail in Canada as An Issue in Modernization." Canadian Public Policy, Autumn 1979, 4, 518-532.

Mallen, Bruce and Associates. "Report on Qualitative Research to Determine Transportation Service Attributes Which Influence Travellers' Mode Decisions." For the Transportation Development Agency, February 1976.

Malone, R. "CTA Cars: No Frills, No Nonsense." Railway Age, May 10, 1982, 22-23.

Manned Undersea Science and Techology Office, National Oceanic and Atmospheric Administration, Department of Commerce. "Manned Undersea Activities of the Federal Agencies and Utilization of Manned Undersea Research Submersibles and Habitats December 1972." Prepared for the Interagency Committee of Marine Science and Engineering Federal Council for Science and Technology, Washington, D.C., April 1974.

Monteil, R.J. "Passenger Comfort and the Physical Environment." Bulletin of the British Psychological Society, 1982, 35, 72.

Moorhead, R. and Lepper, R. "Transit Vehicle Design and Rider Satisfaction." Urban and Social Change Review, Fall 1970, 4(1), 6-10.

Munther, J. "Passenger Coaches for Long-Distance Services: What Future for Bodywork with Extruded Aluminum Sections?" ETR - Eisenbahntech Rundschau, December 1981, 30(12), 923-926 and 929-932.

Myers, B.B. and Marshall, B. "The Influence of Comfort on Passenger Modal Choice in Western Canada." In D.J. Oborne and J.A. Levis (Eds.), Human Factors in Transport Research, Volume 2. London: Academic Press, Inc., 1980.

Myerson, J. and Orna, B. "Transport: On the Right Track." Design, June 1982, 402, 36-38.

Oborne, D.J. "Techniques Available for Assessment of Passenger Comfort." Applied Ergonomics, 1978, 9(1), 45-49.

Oborne, D.J. "Passenger Comfort - Overview." Applied Ergonomics, 1978, 9(3), 131-136.

Oborne, D.J. and Clarke, M.J. "Questionnaire Surveys of Passenger Comfort." Applied Ergonomics, 1975, 6(2), 97-103.

Oborne, D.J. and Clarke, M.J. "Development of Questionnaire Surveys for Investigation of Passenger Comfort." Ergonomics, 1973, 16(6), 855-869.

Ogawara, S. "Study of Riding Quality with New Concepts." Japanese Railway Engineering, 1981, 21(1), 16-20.

O'Neill, W.J. and Krasberg, A.R. "Underwater Submersible Chamber System." Westinghouse Electrical Corporation, Pittsburgh, Pennsylvania, July 20, 1970.

Pandi, G. Train Guide, Europe; The Practical Rail Travel Book. Ottawa: Intertrain, 1981.

Parker, J.C. "Air-Conditioning Related to Passenger Environment." Passenger Environment. The Institute of Mechanical Engineers, London 1972.

Pepler, R.D., Vallerie, L.I., Jacobson, I.D., Barber, R.W. and Richards, L.G. "Development of Techniques and Data for Evaluating Ride Quality. Volume II." Ride Quality Research, U.S. Department of Transportation, DOT-TSC-RSPD-77-1, February 1978.

Perren, B. "How Long Will SNCF's TEEs Survive?" Modern Railways, January 1982, 39(400), 34-36.

Pickup, L. and Town, S.W. "The Role of Social Science Methodologies in Transport Planning." TRRL Supplementary Report 698, Transportation and Road Research Laboratory. Department of the Environment, Department of Transport, Berkshire, England, 1981.

Pratt, R.H. Associates, "Potential Use of Rail Transit by the Physically Disabled in the Washington Metropolitan Area." Kensington, Maryland, April 1972.

Provost, J. "Canadian Railways to The Year 2000: Challenges and Opportunities." Canadian Transportation Research Forum, Proceedings, 1982.

Ravel, J and Bernard, J.P. "Future Internal Service Coaches of the S.N.C.F." French Railway Techniques, 1975, 18(2), 37-56.

Reistrup, P.H. "Amtrak - National Railroad Passenger Corporation - Facts and Goals." Computers and People, 1976, 25(1), 12-16.

Richards, L.G., Jacobson, I.D., Barber, R.W. and Pepler, R.C. "Ride Quality Evaluation in Ground Based Vehicles - Passenger Comfort Models for Buses and Trains." Ergonomics, 1978, 21(6), 463-472.

Richards, L.G., Jacobson, I.D. and Kuhltmau, A.R. "What the Passenger Contributes to Passenger Comfort." Applied Ergonomics, 1978, 9(3), 137-142.

Richardson, J. and Stroud, P.C. "Passenger Requirements in an Automated Transport System." Transport and Road Research Laboratory, Loughborough University of Technology, 1975.

Rubenstein, R., Lohr, R, Brook, R. and Goldberg, G. Conceptualization and Measurement of Physiologic Health for Adults: Vision Impairments. Santa Monica, California: Rand Corp., 1982.

Runte, A. "Blueprint for Comfort: A National Park-to-Park Railway." National Parks and Conservation Magazine, 1976, 50(11), 8.

Russell, J.A. and Ward, L.M. "Environmental Psychology." Annual Review of Psychology, 1982, 33, 651-688.

Seiffert, U. and Walzer, P. "Development Trends for Future Passenger Cars." International Journal of Vehicle Design, 1982, 3(1), 1-20.

Seigel, M. "Design of Pedestrian Facilities for the Washington Metro." Presented to the Metro Association of Urban Designers and Environmental Planners Inc., December 13, 1973.

Sharratt, K. and Mills, R. "Light Rail Transit: A Survey of Community Attitudes, Behaviour and Social Impact Associated With the Light Rail Transit Line from Eglinton/Kennedy to Scarborough City Centre." Prepared for Metropolitan Toronto Planning Department. Toronto, Ontario, September 15, 1975.

Shipley, P. and West, A.E. "A User Opinion Study of the Quality of Railway Carriage Environments." Ergonomics, May 1973, 16(3), 306.

Spring, K.H. "Research and Design with Particular Reference to the Advanced Passenger Train." Passenger Environment. The Institute of Mechanical Engineers, London 1972.

Stimson, T.D. "Supersonic Transports, Too Fast for Comfort?" Popular Mechanics, January 1966, 125, 88.

Stokols, D. and Novaco, R.W. "Transportation and Well-Being: An Ecological Perspective." University of California, Program in Social Ecology. Human Behaviour and Environment: Advances in Theory and Research, 1981, 5, 85-130.

Stone, R.W. "Ride Quality Overview." Proceedings of Symposium on Vehicle Ride Quality. Hampton, VA: NASA-Langley Research Center, July 1972.

Tachet, P. "New Two-Tier Suburban Coaches." French Railway Techniques, 1974, 17(1).

Toth, L. and Pusztai, O. "The Quality of the Services Offered by the Railways in Passenger Traffic." Jarmuvek Mezogazdasagi Gepek Budapest, July 1981, 28(7), 265-273.

Transportation Research Board, 62nd Annual Meeting, Washington, D.C., January 17-21, 1983.

Transportation Research Board, "Innovative Design Features of Washington's Metrorail System." Transportation Research News, (103), Washington, D.C., November/December 1982.

Transportation Research Institute, Carnegie-Mellon University. Improved Passenger Train Service. Proceedings of the Carnegie-Mellon Conference on Improved Passenger Train Service, December 2-4, 1975.

Twidale, P. "Make It Beautiful, But Make It Practical, Too." Transpo 81, Fall 1981.

Ujcic, J. "Comfort - An Aspect of Passenger Service Quality." Zeleznice, Beograd, September 1982, 38(9), 17-26.

Ujcozic, J. "Speed: The Main Feature of the Quality of the Passenger Service in Inter-City Traffic in Jugoslavia." Zeleznice, Belgrade, 1981, XXXVII(8), 29-43.

Van Buchem, P.J.A., Hanenbergh, H., Tappen, E., Kaper,H.P., Vink, G. and de Stever, W. "Public Transport and New Rolling Stock." Openbaar Vervoer, Utrecht, April 1982, 15(4), 112-134.

Via Rail Brochure. "Via Fare All Plan."

Vuchic, V. "Rail Transit in Perspective." Oahu Development Conference, Honolulu, Hawaii, Planning Issues, Fall 1977, X(4).

Vuchic, V. and Potter, T. "Train Crew Reduction for Increased Productivity of Rail Transit." Paper Presented at the 62nd Annual Meeting of the Transportation Research Board, Washington, D.C., January 1983.

West, A., Rammage, F., West, J. and Jones, H. "The Quality of Railway Carriage Environments." Applied Ergonomics, December 1973, 4(4), 194-198.

White, J.H. The American Railroad Passenger Car. Baltimore, Maryland: Johns Hopkins University Press.

Wichansky, A.M. "Effects on the Ride Environment on Passenger Activities: A Field Study on Intercity Trains." Dissertation Abstracts International, April 1979, 39(10-B), 5117-5118.

Wolfe, R. and Miller, E. "Long Range Transportation Planning for Seniors in Ontario." Paper Submitted at the 62nd Meeting of the Transportation Research Board, Washington, D.C., August 1982.

Wood, S. The Railway Revolution. London: Macmillan Publishers, 1981.

No Author "A New Double-Deck Commuter Car." Advertisement from Hawker-Siddeley Canada Ltd.

No Author "Advanced Concept Train." Advertisement Booklet from U.S. Department of Transportation. Boeing, Garrett, and Airesearch Manufacturing Co.

No Author "Africa's Fastest Trains Arrive This Month." Railway Gazette International, March 1983, 187.

No Author "Amtrak Advertisement." Railway Age, August 10, 1981.

No Author "Amtrak's Double-Deckers Exploit Modular Design Limits." Railway Gazette International, June 1977, 133, (6), 228-229.

No Author "Automated Light Transit in Three Cities." Railway Gazette International, April 1983, 139(4), 265-266.

No Author "CN Passenger Business Up in '76." Montreal Gazette, February 1, 1977.

No Author "CTA Cars: No Frills, No Nonsense." Railway Age, May 10, 1982.

No Author "Camden to Philadelphia in 0:05 WABCO Time." Advertisement in Modern Railroads, May 1975.

No Author "Centennial Trains West: Fun and Friendship in Comfort." American Libraries, May 1981, 12, 282.

No Author "Charles de Gaule Rail Inaugurated." TD (A) News, August 1976, 25-26.

No Author "Clayton Charts a Course for Amtrak." Railway Age, January 1983, 43-45.

No Author "Design for People." Defence and Civil Institute of Environmental Medicine. Prepared for the National Design Council of Canada, Ottawa, 1975.

No Author "Directive for the Guidance of the Canadian Transport Commission on Rail Passenger Services." Transport Canada, January 29, 1976.

No Author "Does It Have to Be This Way - Research in Gerontology." Research Development and Administration, University of Michigan, Research News, November 1975, 26(5/6).

No Author "Egyptian Turbos Will be Africa's First 160 km/h Trains." Railway Gazette International, February 1983, 80.

No Author "Environmental Design: Research, Theory, and Application." Proceedings of the Tenth Annual Conference of the Environmental Design Research Association, Washington, D.C., May 1979.

No Author "Fares Too Low." Railway Gazette International, June 1983, 410.

No Author "High Speed Trains en Route to Profit." The Globe and Mail, June 6, 1983.

No Author "Holidays by Rail in the British Isles." Modern Railways, March 1983, 146-147.

No Author "Holidays by Rail in Europe." Modern Railways, February 1983, 97-100.

No Author "Holidays by Rail Beyond Europe in 1983." Modern Railways, January 1983, 27-29.

No Author "Inter-city Towards Viability." Modern Railways, April 1983, 212-213.

No Author "Le Comfort du Passager de Vehicule Ferroviaire; Problematique et Methode d'Approche." Revue Generale des Chemins de Fer, April 1983, 189-196.

No Author "Low Profile Coaches Make their Debut." Railway Gazette International, June 1981, 500.

No Author "Lyntog MK3 - Denmark's New Generation of Inter-City Train." Modern Railways, November 1982, 39(410), 506-509.

No Author "News From Industry." Rail International, July 1983, 8-9.

No Author "Paper on a Canadian Rail Passenger Program." Transport Canada. January 29, 1976.

No Author "Passenger Transport." America Public Transit Association, 34(14), April 2, 1976.

No Author "Passenger Transport." Washington DC, April 12, 1974, 31(15).

No Author "Public's Attitudes Have Changed: Today the Train is Replacing the Second Car." Railway Gazette International, February 1983, 96-97.

No Author "SD3-30 Air Taxi Planned for Passenger Comfort." Aviation Work, February 24, 1975, 102, p52.

No Author "South Shore: A Good, Basic Car." Railway Age, May 10, 1982.

No Author "Summer Travel by Canadians." Transport Canada, August 1980.

No Author "The Business of Travel." Management Today, March 1983.

No Author "The Future Role of Rail - A Policy Position." Ontario Task Force on Provincial Rail Policy, October 1980.

No Author "The New Standard IV Coach." SBB Nachrichtenblatt, Bern, October 1981, 58(10), 155-159.

No Author "The Next Metro: France's Train to Tomorrow." Time, 82, May 2, 1983.

No Author "West Germany Invests in Magnetic Trains." New Scientist, December 1981, 92, (1282), 651.

No Author "World's Fastest Tilting Train Enters Service." International Railway Journal, January 1982, 22(1), 14-19.

No Author "Zurich Chooses Double-Deckers." Railway Gazette International, February 1983, 81.

References for Interim Report C and Interim Report E

Current Canadian Practice (Interim Report C)

1. "Railroad North", by Roger Newman, Transpo/83, Vol. 6/4, 30-33.

2. "VIA Rail's new push", by Michael Clugston, Maclean's, Oct.17, 1983, 20-20b.

3. "More LRC's will bolster VIA's corridor services", by Ken Norman, The Globe and Mail, September 19, 1983, B9.

4. VIA Customer Services, August,1983, Summary of Complaints, internal memo.

5. VIA Sleeper and Day-niter car descriptions (two page descriptions for each of 10 car types), from Mr. A.J. Caird, Regional Mechanical Officer, Toronto.

6. "Dockside 83", Special supplement to Canadian Yachting and Sailing News for the Dockside 83 show, September 15 to 18, 1983.

7. "XLs...the 'roomier' is true", Prevost Car, Inc. Coach Manufacturer, promotional brochure.

Comparison of Canadian and International Railway Practices (Interim Report E)

Transport Canada, January, 1976 -
Paper on a Canadian Rail Passenger Program

Economic Analysis Directorate, Transport Canada, December, 1983 -
Freight and Passenger Forecasts 1983

Lukasiewicz, J., 1976 -
The Railway Game, McClelland and Stewart Limited, Toronto

Lukasiewicz, J., June, 1983 -
article in The Globe and Mail

Day, John, 1981 -
The Transcontinental Train in Western Canada: An Innovative Alternative

Science Council, Transportation Research Group, May, 1982 -
Passenger Rail Equipment for Canada, Science Council Working Paper on Intercity Passenger Transportation

Appendix A
Sources of Information

Behavioural Team sent approximately 100 letters to
a) manufacturers of yachts, buses, and travel trailers, and
b) operators of railways, cruiseships, airlines, bus lines, and ferries.

In addition, we made numerous telephone calls and personal visits to conduct interviews or find information. The following lists those persons and companies who responded to our letters, calls, or visits. We are grateful to all of these sources for the information they provided, and apologize to anyone whose name or official title may have been inadvertently omitted.

Persons providing information regarding current Canadian practice

Rail

VIA Rail Inc.: Tim Secord, Development; Pamela Rice, Marketing; Lise Poitras, Jay Smith, Customer Services; Bill Fitzgerald, Roy Arnold, Onboard Services; Barbara Downey, Engineering Library - VIA Rail Head Office, Montreal
Al Caird, Gameney Gooray - Operations, Toronto
Vern Thomas, Bill Drury - Spadina Yard, Toronto
Hawker-Siddeley Inc.: J.W. Ferguson, Engineering

Bus Lines

Voyageur: Paul Bateson, Operations Manager
Graycoach: Mr. Galinis, Operations Manager
Greyhound: Tony Lynd, Operations Manager

Bus Manufacturer

Prevost: Michael Rochette, VP Sales and Marketing

Ferry

CN Marine: J.L. LeBlanc, Mgr. Marketing Services

Yacht Manufacturers/Dealers

C&C Yachts Limited: Roderick L. Gerrard, Director Corporate Design
Pilgrim Marine Sales Inc.: Gary Ferguson, Sales

Recreational Vehicle (Travel Trailer) Manufacturers

Canadian Recreational Vehicle Assoc. (CRVA): Harrold Young, Executive Assistant
Fleetwood Canada Ltd. (Lindsay, Ont.): Norm Smith, V.P. CRVA

Persons providing information regarding current international practice

Railways

Australia - D.G. Williams, Australian National
Britain - J.S. Cousins, British Railways Board
Denmark - J. Nielsen, A. Lovenkjaer, H. Christensen, DSB
France - Msrs. Tessier, Bouvet, Bonfils, Meyers, SNCF
New Zealand - H.Purdy, New Zealand Railways
Spain - El Jefe de Estudios y Relaciones con las Medios de Comunicacion (Chief of media studies and relations), RENFE
Sweden - P. Molander, D. Van Berlekom, S. Fryklund, G. Nilsson, SJ
Switzerland - W. Baumgartner, P. Ueltshci, SBB
West Germany - V.B. Rasche, H. Moller, DB
USA - C.J. Engelhardt,Amtrak
B. Williams, J. Martin, National Assoc. of Railroad Passengers

Airlines

Air Canada: C. Dobias
American Airlines: A. Kuhner
CP Air: Passenger Relations
Wardair: Capt. D. McKinlay

Cruiseships

CN Marine: R. Cameron, Manager Public Relations;
L. LeBlanc, Manager - Marketing Services
Carnival Cruise Lines: K. Armstrong Musiel, Vice President - Marketing;
C. Broom Farcus, Designer
Cunard Line Ltd.: S. Strebel, Passenger Services;
J.M. Hanbridge, Sr. Vice President
Delta Line Cruises: F.K. Kappler II, Principal - Lowry & Partners
Holland America Cruises: Willem Prins, Vice President - Marine Hotel
Norwegian Carribean Lines
Princess Cruises
Society Expeditions Cruises Inc.: General Manager, Seattle WA
Scandanavian World Cruises: General Manager, Miami FL
Windjammer Barefoot Cruises: General Manager, Miami Beach FL

Industrial Design Consultants

Kuypers Adamson Norton Inc.: Jan Kuypers and Ian Norton

Ernest Wotton, lighting consultant

Other Sources of Information

Canadian Institute for Guided Ground Transport (CIGGT)

Canadian Standards Association: Patrick Yee, Sr. Engineer

Defense and Civilian Institute of Environmental Medicine (DCIEM): David Beavis, Stan Forshaw, Les Innes, Anthony Cheung

Standards Council of Canada: Mr. Barsoum

Statistics Canada: Angus MacLean, Gord Baldwin, Barbara Slater, Economics Division, Transportation and Communications Section; Bob Chadwick, Education, Culture, and Tourism Division, Travel, Tourism, and Recreation Section

York / U of T Joint Program in Transportation: Ed Dosman, Eric Miller

University of Guelph, College of Family and Consumer Studies: Anne Wilcock